The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

Edited by LEON GASTER

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EDITORIAL.

Progress in the Past Year.

It has been our custom to present in the January issue a review of progress during the past year. During the war there was not much to be recorded on such occasions, but we have now behind us the first complete year that has elapsed since the signing of the Armistice, and it is of interest to take a general review of developments in Illuminating Engineering during 1919. It will be convenient to deal first with progress in appliances for producing light, secondly with their useful application.

Progress in Lamps and Lighting Appliances.

To some extent these developments have been already noted in the Report of Progress presented at the opening meeting of the Illuminating Engineering Society last November, and in the comprehensive survey made by the Committee on Progress in Lamps and Lighting Appliances on that occasion. It seems clear that for some years to come makers of lighting appliances will have plenty to do. During the past year the demand for special war purposes has been replaced by an equally insistent demand for normal applications in the service of peace. Many schemes and developments held over during the war will now be proceeded with, and there is no

immediate prospect of a slackening in this respect. Similarly the depletion of stocks in many localities abroad should stimulate exports, even allowing for the formidable competition from other countries and the difficult economic position at the present time.

Much has been said regarding the fuller application of science to industry arising through the needs of the war, and it must be freely acknowledged that in many cases great resource has been shown in producing articles manufactured, either not at all, or on a very small scale, in this country in pre-war years. We believe that the experience so gained will be valuable, and there is no doubt that as regards many articles needed in the lighting industry the facilities for manufacture have been much extended. But it remains to be seen how far articles made under quite exceptional economic conditions at a relatively high cost and in insufficient quantities can now be manufactured profitably on a commercial scale. So far as the manufacture of electric lamps and gas mantles is concerned there has been undoubted progress. But one of the weakest points has been the sustained difficulty in making adequate supplies, of good quality, bulbs for electric lamps, and glassware needed both in gas and electric lighting. It is recognised, however, that difficulties were imposed on manufacturers by the urgent demands for other forms of glassware needed for war purposes. In view of the important developments that are now taking place in the glass industry, and the reported introduction of more efficient methods of manufacture, we hope that expectations of an early improvement in this direction will be realised. As regards metal reflectors, utilised mainly for industrial purposes, the prospects of completely satisfying the present demand seem promising. We dwell on this point because it is obvious that the general application of correct lighting principles is entirely dependent on an adequate supply of globes, shades and reflectors, besides the actual sources of light, being available.

In the war period there was naturally little leisure for manufacturers to develop radical departures in illuminants and lighting appliances. Their attention was concentrated on meeting the urgent demand for standard articles—a condition that was general throughout the world. We see no reason why British manufacturers should not ultimately hold their own simply on the basis of cheap and efficient production. But it is obvious that a more hopeful, and probably less harassing, method of gaining pre-eminence is to be in the vanguard of scientific discovery. It was in this way that the unique position this country held in the field of artificial lighting was originally established. In gas lighting the lead was taken by the enterprising encouragement of an entirely new and, at that time, almost incomprehensible principle of *distribution* of the means of lighting through piping—years in advance of other countries. In electric lighting Sir Joseph Swan's discovery of the incandescent lamp, only paralleled by Edison's work in the United States, secured for this country pre-eminence in Europe.

We earnestly hope, therefore, that the lessons so well conveyed at the British Scientific Products Exhibitions of the last two years will be endorsed by firms in the lighting industry; that, during the next few years the foundations of future prosperity in the lighting industry will be laid by the proper development of scientific research; and that due encouragement will be given to those engaged in research so that they may receive an adequate return for their efforts in advancing the lighting industry in this country.

Progress in Apparatus for measuring Illumination.

A feature during the past year has been the interest taken in apparatus for measuring illumination. The methods used in the special instruments designed by the Committee of the Illuminating Engineering Society for testing flares, parachute lights, etc., during the war may be applied, in a modified form, to ordinary purposes. A new form of instrument was recently shown before the Society by Mr. Haydn T. Harrison on November 25th, while in the United States there are now several new types which have come into use since the outbreak of war.

The circumstances in which apparatus for measuring illumination are applied and the number of purposes they serve are now so varied that there is room for quite a number of different forms. In each case a decision has to be taken as to the relative importance of accuracy and convenience. The tendency now is towards the design of very simple and portable instruments, in some cases allowing a reading to be taken by mere inspection of the scale without moving a lever to obtain balance. Such types form a valuable supplement to the more precise and accurate forms. One might suggest a rough classification into "illumination-photometers" and "illumination-gauges," the latter serving merely to enable a rough determination of the order of illumination to be obtained with extreme ease and being suited to particular problems. For example, instruments for use in accurately determining conditions of illumination in streets, factories, picture theatres, mines, etc., demand qualifications that can only be met by a very comprehensive form of apparatus capable of adjustment according to the problem dealt with.

The Study of Lighting in the Public and National Interest.

We lay stress on the importance of apparatus for measuring illumination because of the part it is destined to play in recommendations and regulations made in the public interest. A marked feature during recent years, and especially in 1919, has been the growing recognition that in a large number of cases definite recommendations are needful for the convenience, health, and safety of the public. The introduction of codes on factory lighting in a number of States in America has greatly stimulated the production of instruments suitable for measuring industrial illumination. Similarly the researches of the committees of the Illuminating Engineering Society dealing with lighting on railways and conditions in cinema theatres depend essentially on measurements of illumination.

Other matters of topical interest in which the Society is concerned, such as lighting conditions in mines and automobile headlights, again require the accumulation of illumination data before definite recommendations can be made. Again, it will be recalled that in the paper on "Street-lighting Reconstruction," read by the author before the Illuminating Engineering Society last year, one of the chief suggestions was that a survey should be made of the conditions of illumination in various classes of streets in order to ascertain to what extent they complied with the requirements under the draft Standard Specification for Street-lighting.

All these are instances of lighting problems which come under the direct notice of various authorities. In many cases, too, private societies and associations can do a great deal to help. We should like to mention especially the useful work of the British Industrial "Safety First" Association in this direction.

The Art of Camouflage.

In this number we are presenting the lecture delivered on the above subject by Captain W. A. Howells, O.B.E., before the Illuminating Engineering Society on December 16th, and also (pp. 13–16) recent communications by Mr. M. Luckiesh and Lt.-Commander Norman Wilkinson dealing respectively with camouflage from the standpoint of aircraft and the "dazzle-painting" of ships.

The whole subject is one of great interest to the illuminating engineer, including as it does problems involving both physical and physiological considerations. Captain Howells, who confined himself to the camouflage of stationary objects on the surface of the ground, insists on the importance of deception rather than concealment. It is practically impossible to conceal completely operations covering any extensive area. Concealment might have been possible in the past, but the whole problem is altered by the far-reaching development of observations by aircraft. At sea, again, the idea of trying to render the hulls of ships inconspicuous was apparently abandoned, and later developments took the form of painting them with such curious patterns as to mislead hostile vessels as to their nature and course.

One very interesting point, brought out both by Captain Howells and by Mr. Luckiesh, is the difference in the appearance of areas covered by vegetation, or otherwise having an irregular surface, when viewed respectively from the ground level and from a great height. Growing grass, for example, when viewed laterally appears brighter than when observed from above, often the fact that the interstices between projections are in shadow. In general, therefore, areas covered with vegetation may appear abnormally dark, whereas smooth ones (well trodden roads, for example) appear very bright and well defined by contrast. Similarly grass that has been pressed flat or trodden down appears as a brighter patch, and this effect requires to be very carefully guarded against. Readers will also be much interested in the various devices, such as sheets of netting, etc., by which the boundaries of conspicuous objects are confused, and in the effects of shadow which, varying much at different times of the day, may reveal otherwise unsuspected projections. Yet another point to be noted is the distinction between visibility to the eye and appearance as recorded by the photographic plate. The latter may often reveal things that the unaided eye can barely distinguish, especially when special colour filters are used to eliminate the effects of mist.

The experience gained during the war in this field should be carefully treasured. In view of the prospective development of aerial navigation in time of peace much of this information may have an important bearing on the converse problem, *i.e.*, the marking out and painting of objects so as to be easily recognisable from above. In the day-time the choice of colours, the design and dimensions for landmarks, intended to enable aviators to recognise their whereabouts will be a matter of great importance, while the establishment of similar luminous recognisable devices by night may well open out an entirely new branch in illuminating engineering, which will require treatment on an international basis. This is a subject which might profitably be taken up by the Illuminating Engineering Societies in various countries in conjunction with the Government Departments concerned with aerial traffic.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE ART OF CAMOUFLAGE.

(Proceedings at a meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, December 16th, 1919.)

A MEETING of the Society was held as stated above, the PRESIDENT (Mr. A. P. TROTTER) in the Chair.

The Minutes of the last meeting having been taken as read, the Hon. SECRETARY read out the names of the following applicants for membership :—

Members—

Fry, A. E. .. .. Manager of the Burner Dept. Plaissetty Manufacturing Co., Ltd., Leyton.

Hood, J. .. .. Edison Swan Electric Co., Ltd., Ponders End, Middlesex.

Medlock, J. G. .. .. Plaissetty Manufacturing Co., Ltd, Leyton.

Associates—

Baker, Miss F. E. .. Manager of Research Laboratory and Director of Tintometer, Ltd., Salisbury.

The Hon. SECRETARY also read out again the names of applicants announced at the previous meeting on November 25th, who were formally declared members of the Society.*

The PRESIDENT then called upon Captain W. A. HOWELLS, of the Camouflage Camp, Larkhill, Salisbury Plain, to deliver a lecture on "**The Art of Camouflage.**" The lecture proved of great interest, and was illustrated by a large number of lantern slides, showing typical camouflage problems. Captain Howells replied to points raised in the discussion; and a vote of thanks to the lecturer terminated the proceedings.

It was announced that the **next meeting** would take place at **8 p.m.** on **Tuesday, January 27th,** when a discussion on "**Colour-matching by Natural and Artificial Light**" would be opened by **Mr. L. C. Martin** (of the Dept. of Technical Optics, Imperial College of Science and Technology.)

* ILLUM. ENG., Nov. 1919, p. 311.

THE ART OF CAMOUFLAGE.

By Captain W. A. Howells, O.B.E.

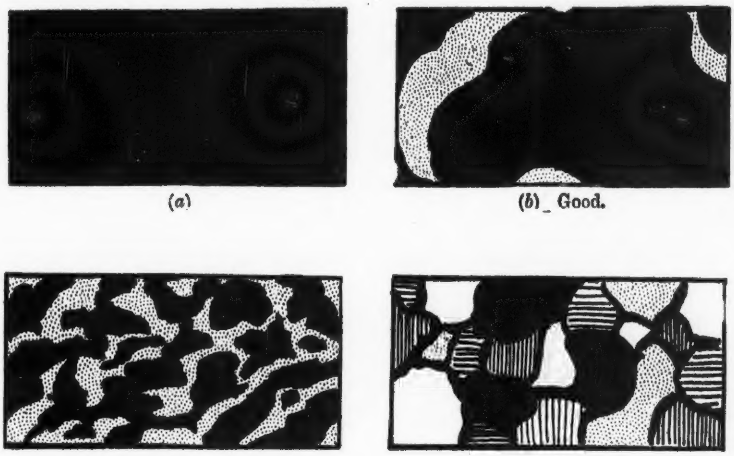
(Summary of an address delivered before the Illuminating Engineering Society at the meeting held at the House of the Royal Society of Arts, London, at 8 p.m. on Tuesday, December 16th, 1919.)

It cannot be too strongly impressed that the essence of camouflage is deception; that it represents a definite attempt to deceive an enemy and is not adapted for the purpose of securing protection from view. One of the chief causes of the indifferent efforts during the early part of the war was that camouflage meant concealment from view. A gun can be concealed under a sheet of tarpaulin but it is not camouflaged. A hare lying up in a furrow of a ploughed field is camouflaged by nature; though it is visible it is not distinguishable. In the early days of the war attempts were made to paint important buildings with comparatively minute spots all the colours of the rainbow, the idea being that viewed from the correct distance the colours would merge and assume an even tone. Anyone with only an elementary knowledge of colour physics knows this to be the case, but it would have saved a great deal of time and expense if the buildings had been painted in one even tone. The fact that they were covered with many-hued spots only served to advertise the fact that there was something to be bombed by the enemy.

It was soon discovered that the only method of painting was the disruptive, *i.e.*, painting in large patterns so as to distort the shape of an object, and it was then only of use against optical observation and of no assistance in defeating the camera. It is useless painting objects with the idea of preventing their showing up against the sky. Paint is only of use in merging an object into its background. It will not reduce a silhouette.

If we are to destroy the shape of an object we must treat the edges. Too large a quantity of light tone on the edge will give excessive relief against a dark background, and *vice versa*.

We must make a design based on the nature of the surroundings and it should be adjusted to contradict the shadow and not to emphasise the shape, *e.g.*, we should not paint a design with horizontal and vertical masses on a rectangular building but the pattern should have a diagonal tendency. It has been suggested that all under portions which are normally in shadow, should be painted light to neutralise the shadow. This counter-shading is found in most living animals, those parts of the animal that are always in shadow are light-coloured. It is possible that, as viewed by many animals, the depth of shadow is minimised and vagueness produced. In this connection it is difficult to lay down any hard and fast rule, and I feel bound to express the opinion that rather too much stress has been laid on this art of painting and applying it to buildings, guns, etc. We must not forget that animals are not all the same height, and what would render a rather vague form to a rabbit would not give the same effect to a giraffe. The line of vision of the rabbit is what we would call the horizontal view and the giraffe would be more of the aerial! No doubt valuable lessons can be learnt from the study of animals, but the camoufleur must be careful in his selection of examples.



(a) (b) Good.

(c) (d) Bad.

FIG. 1.—Illustrating use of Disruptive Patterns in Camouflage.

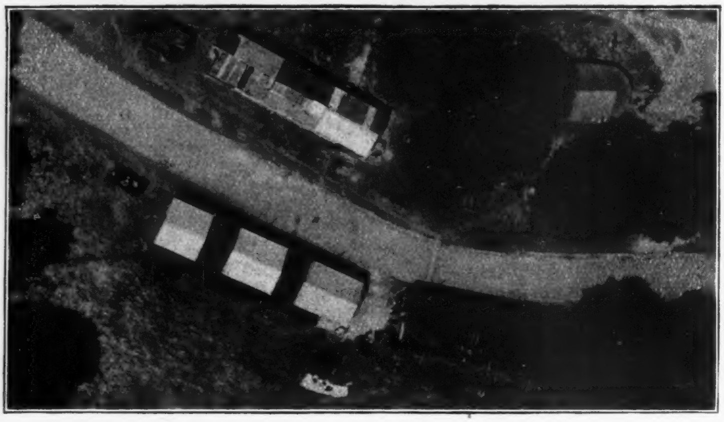
A fact not to be lost sight of is that even in nature protective colours and patterns are of the greatest use when the animal, bird or insect is at rest, and in the latter connection there are some wonderful examples to be seen in the Natural History Museum, South Kensington. You may paint a building or gun to merge into a background, but in the case of the gun its effectiveness is destroyed immediately it is moved. You will see, therefore, that it is impossible to standardise patterns for this particular branch of camouflage. To give an idea of the use of the *disruptive* pattern the sketches reproduced in Fig. 1 should be studied.

It must be remembered that the camoufleur's greatest enemy is the shadow and no matter how cleverly an object be painted to deceive the eye of the observer the shadow will always be in evidence in the photo. It may be asked why the shadow plays such an important part in the photo and is not of much assistance to the observer. The answer is that, speaking generally, the shadows in the aerial photo are generally under-exposed and so make a greater contrast to the object than appears to the eye. Remember also that the photographs are studied at leisure in safety, whereas the enemy airman is generally worried by anti-aircraft guns, and was not created to compete with the nerveless camera which can make a good reconnaissance in 1/125 of a second.

The problem of the elimination of shadow was considered, and while the methods adopted for screening comparatively small objects such as guns, etc, from optical and photographic observation were successful, it was found impossible to apply the principle to large buildings, the structural difficulties being too great. It was decided to treat the roofs of buildings in such a way that their visibility was lowered. Owing to the smooth construction of the roofs of most buildings a considerable amount of light was reflected, and on a moonlight night this was of great assistance to the enemy bomber in locating them. A simple method was to tar and sand the roofs; this made a matt surface which reflected very little light and was completely effective at night. Another method was to tar the roofs and lay grass or hay on.

Table I. classifies roofing materials in order of effectiveness for concealment.

It would be interesting to know the percentage of enemy bombs dropped on suspected spots at night as against positively known targets in our towns. There is no doubt that in the smaller towns the war-time lighting arrangements were good, but that did not prevent damage being done by the enemy airmen, more often than not to buildings of no military importance at all and, as we all know, frequently inflicting casualties to non-combatants. Take any town where there were munition works. Would it not have been possible to have fitted up an arrangement on ground some distance from the works and a plan made of the works with lights so as to attract the enemy bomber? No great expense would have been incurred and the cost of lighting would have been small as it would have been used only when an air raid was suspected. This is only another use of the "dummy" position often employed by gunners. It



Textured sections. Textured hut.

FIG. 2.—Illustrating treatment of roofs of buildings

TABLE I.

ROOFING MATERIALS CLASSIFIED FOR EFFECTIVENESS IN CONCEALMENT.

Name of material.	Texture.	Colour (unpainted).	Night visibility 1,000′ Moon 45°.	Day visibility.
Corrugated iron ..	Rough	Grey black (always painted)	Invisible	Inconspicuous
Tarred felting ..	Dull	Black	Invisible	Inconspicuous
Penrhyn slates ..	Fairly rough	Dark grey	Invisible	Inconspicuous
Port Madoc slates ..	Fairly rough	Dark grey	Invisible	Inconspicuous
Callenders' asphalt roofing	Fairly smooth	Dark grey	Just visible	Fairly obvious
Red tiles	Smooth	Red	Lighter than grass	Dangerous
Bell's roilite ..	Very smooth	White	Clearly visible	Very bad
Ruberoid	Very smooth	White	Clearly visible	Very bad
White asbestos ..	Perfectly smooth	White	Abnormally visible	Abnormally visible

would surely have attracted the enemy and induced him to drop his bombs on the spot, no other target being so visible. Care would have been taken to see that the lighting was not overdone. As illuminating engineers it would be well for you to study this aspect of lighting in case you are called upon to devise some scheme to cope with the conditions of war.

From the slides you have seen you will understand that to obtain depth of tone in a photo it will be necessary to use a rough-textured material. If you remember that smooth canvas photographs white and that gorse gives the darkest tone of all—nearly black—you should form some idea what materials make intermediate values.

The aerial photograph of the landscape underneath (Fig. 4) gives a good idea of the various tone values of different growths of vegetation. You have the lightest in the smooth roadways and the darkest where the vegetation is roughest. This photograph shows the value of the shadow when estimating height and character of objects which I shall mention later on. Untrodden grass photographs a dark tone due to the upstanding blades casting shadows—quite different to the horizontal appearance where most of the light is reflected or refracted. Grass pressed flat naturally reflects light upwards and that is why tracks show a lighter tone. The slightest disturbance in a field originally photographing an even tone is shown up with remarkable distinctness by the camera.

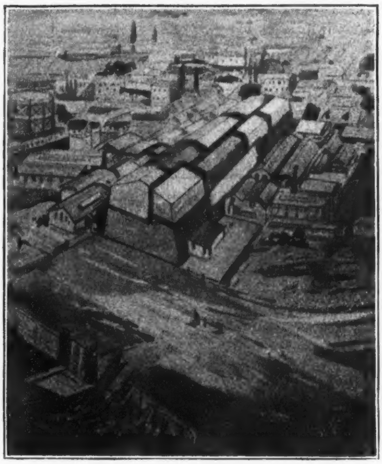


FIG. 3.—A method of painting a large building.

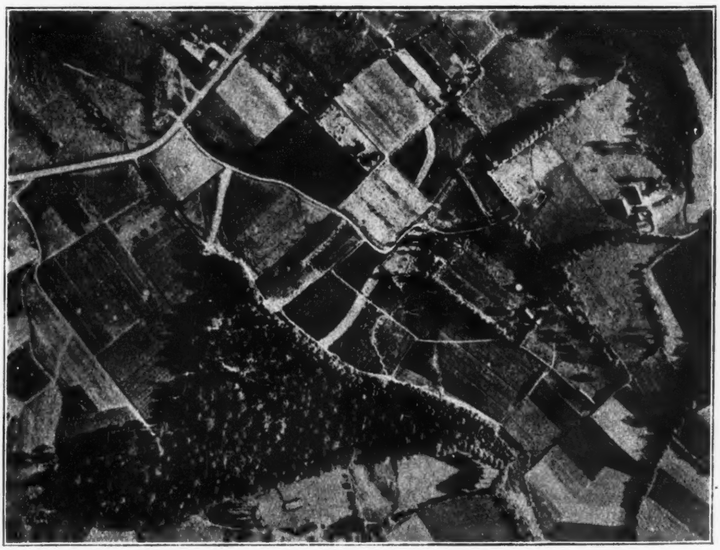
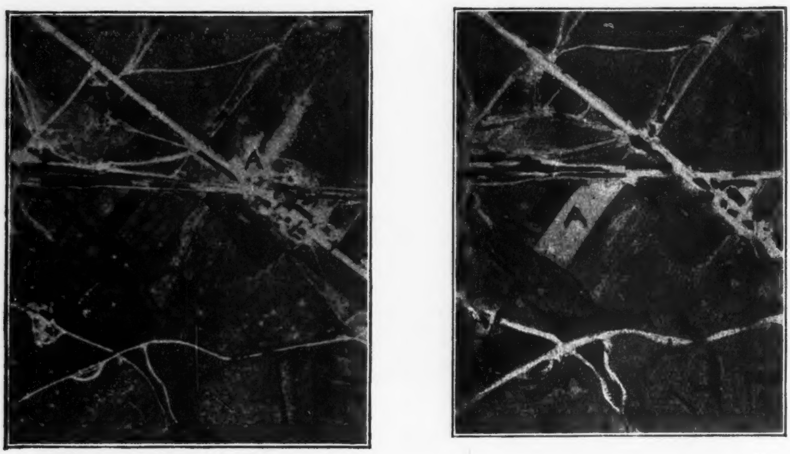


FIG. 4.—Aerial photograph showing various tone values of different growths of vegetation.

The study of tracks is all-important to the intelligence officer. They record movement of troops with unerring accuracy and it was only during the later phases of the war that something was done to educate troops to understand that in trench life and battle preparation all movements should be in conformity with the checkered design of the landscape, and that tracks should not be made to run diagonally across fields. The lines of demarkation of fields were clearly defined in the photographs (see Fig. 4), up towards the edges and the wear of the traffic would have completed the effect from the air of a ploughed field. Now the tone of the plough in a photograph always tends to lightness, and it follows therefore that tracks being of the same value they would be very difficult to see in a photograph, if at all. This device would be useless if the converging tracks had been made beforehand. It was only by disciplinary measures that troops were made to keep to the roads or existing paths.



The dump at **A**. A better choice.

FIG. 5.—Showing selection of position for dump.

and men were taught to make use of them such as walking alongside hedges, on the north side if possible, the shadows of the hedges being helpful in blotting out any suspicion of a track. The earlier photographs taken during the war often show innumerable tracks from all directions converging on some point which if near a road and railway generally indicated the position of a dump. The irregularly worn area made by constant traffic could have been avoided very easily if, when siting the dump, care had been taken to choose a field which was of a rectangular pattern. Having fixed the boundaries of the dump by means of fencing of some sort, the turf or undergrowth could have been taken

In the following photograph (Fig. 6) you will see signs of a great deal of traffic leading to the copse and seemingly less going out the other side. It is most suspicious. If the copse had to be used at all it would have been a good thing if a clearing had been made right through, creating a line which would appear to be the effect of traffic and then there would be some chance of misleading the enemy reader.

A source of revelation in the detection of batteries is the blast mark, *i.e.*, the removal of the earth in front of the guns by the force of the blast. These photograph a light tone and six of them in line would at once give away a position and render nugatory any good camouflage

that may be fixed over the guns. If the gun can be sited so as to fire over a road, bare earth, or water, the blast mark will not be detectable. For one or two guns the best thing in the open country is to fire over shell holes.

Attention must be paid by the camoufleur to the change of seasons and the varying tones assumed by vegetation, etc., in its growth.

I know of one case where German gunners had camouflaged their position well, but it was revealed in a photograph taken sometime after when some vegetation had grown, showing the covering of the guns as light rectangular patches. The original background of the earth was light and the Germans had neglected to alter the covers. Another case I have in mind is a German gun position which had been covered in with turf taken up in the immediate vicinity. The turfless ground showed up in the photograph as rectangular patches. The men had done the work too neatly, and the straight lines being unnatural led to the discovery of the guns. Not very far behind these guns were a great many shell holes. As you have seen, they photograph something like stars with a dark centre. Remembering the dark tone of grass, the men could have left circular pieces and cut the turf irregularly around them and made some idea of shell holes. At any rate they would have photographed well and been quite passable.

In the examples I have shown on the screen no doubt you have noticed that the Germans were very careless in their preparatory work. They commenced operations without cover of any kind, with the result that our airmen were able to photograph the various stages of concealment.

This is fatal to successful work, and it is essential that camouflage screens be erected first and the men kept under cover as much as possible, care being taken that tracks are not made beyond the area of the overhead cover. This is much more difficult than it seems.

The best aerial photographs were taken in the morning or the evening, when the shadows were long. By that means one could estimate the height of ruined walls and the possibility of the enemy concealing himself. It is very difficult to distinguish objects amongst ruins owing to the shadow being distorted by the debris. For this reason howitzers placed in ruined villages would stand an excellent chance of escaping observation. In the absence of any camouflage gun-covers such as you have seen, gunners made the fullest use of this knowledge and were able to stay in positions without detection.

FIG. 6.—Showing signs of traffic near copse.

Advantage was also taken of the already disturbed ground by troops when selecting sites for new work. As I have stated, disturbed and worn ground were generally of a light tone in the photograph and formed an excellent background on which to operate. Such things as buried cables, for instance, instead of taking a diagonal line across country, followed the line of trench or rectangular shapes of the fields the same as tracks. I want to say a word about the type of plate which was used in aerial photography. It was a panchromatic plate which showed up trenches a much lighter tone than the ordinary plate and any suspicion of new work was set at rest by the use of it. The panchromatic plate was particularly useful at the Camouflage School in the winter time, when the sun was yellow, and it was possible on a day when there was a ground mist to take good photographs of experiments at a height of 1,000 ft., using a red screen and the lens at full aperture.

You will now understand why the camera plays such an important part in modern warfare. There are still many problems to be solved, the most difficult being a type of gun-screen that will defeat the stereoscopic view. During the later stages of the war stereoscopic photographs began to play a great part in aerial reconnaissance. The earlier attempts in this direction were not satisfactory as the base line was much too short, having regard to the height at which the photographs were taken. The ordinary stereoscopic camera was useless at a height of 8–10,000 feet, the altitude at which photographs were generally taken, the distance between the lenses being much too short to obtain any relief of objects on a battlefield. I believe the next step was the fixing of a camera on the end of each plane with an arrangement for making simultaneous exposures of the plates. This was not satisfactory, the cameras being still too near. It was found that an observer making a few exposures in quick succession at approximately the same height with the same camera was able to produce photographs, two of which would generally register in the stereoscopic viewer. If six were taken when the observer was flying straight, it would be found that Nos. 1 and 6 combined would often give exaggerated relief of breastworks, guns, etc.

The photographer will tell you that you cannot defeat his camera, but I feel sure something can be done in the direction I have indicated. No serious effort has been made so far.

FIG. 7.—Showing new work in trench.

A great deal of experimenting remains to be done with filters in conjunction with panchromatic and other plates sensitive to single colours, and also the use of goggle filters for the detection of camouflage.

(a)

(b)

FIG. 8.—Showing value of a red screen, used in conjunction with panchromatic plate, in cutting out fog.

As showing the value of a red screen in cutting a fog, some photographs taken in Kensington Gardens on November 26th, 1918 (Figs. 8*a* and 8*b*) will be interesting.

Ordinary Plate.	*Panchromatic Plate.*
Time: 9.30 a.m.	Time: 9.30 a.m.
Exposure: 1/25 sec.	Exposure: $\frac{1}{2}$ sec.
Stop: 5.6.	Stop: 5.6.

DISCUSSION.

In the discussion various speakers alluded to camouflage problems likely to be met with in the future, and especially to the difficulty of concealing large cities in view of possible aerial attack.

Mr. J. Murray Kendall said that he was exceedingly glad to notice the emphasis laid on track discipline by the lecturer, for he quite agreed that no effective camouflage had ever been discovered for the tracks left even by small parties. It was for this reason that certain theories, as to the possibility of massing large bodies of troops under cover of vast areas of camouflage materials made to resemble the natural surface of the earth, might be regarded as fallacious. The carrying parties bringing up, and the fatigue parties manipulating the materials for works of such great extent would inevitably produce tracks of so pronounced a nature as to draw attention to the very areas which it was desired to remain unnoticed. There was, moreover, no evidence that anything of this sort was ever attempted.

Capt. C. H. Moore inquired whether the lecturer anticipated that the art of camouflage would eventually be able to deal effectively with positions close to a large or distinctive tract of water. They all knew that the surface of water shows up distinctly against any surroundings, whatever the lighting conditions might be.

With regard to a previous speaker's reference to "the camouflage of moving objects" they had the early instance in "Macbeth," where "Birnam Wood" came to Dunsinane," covering an approaching force.

Mr. B. B. Walker inquired whether attempts had been made to obtain information regarding the nature and height of objects by taking photographs of the same piece of ground from different points in the air.

Mr. A. W. Wyatt referred to the view expressed that the methods of shading lights originally used in London during the war period had the effect of making streets more prominent when inspected from above, than they would have been under normal conditions. If some light had been allowed to escape upwards the diffusion of this light in the atmosphere over the city would have produced a luminous haze, rendering it difficult to identify particular objects, although the airman would recognise more easily when he was over London as a whole.

Mr. L. Gaster alluded to the converse problem that would be met in connection with peaceful aerial navigation, namely, producing an appearance of prominent objects and landmarks such that they could be readily recognised from above and so enable the airman to recognise his whereabouts.

The President, in closing the discussion, referred to his own experiences in connection with the masking of lights in London as a precaution in connection with air-raids, which had been dealt with in his presidential address before the Society in 1917, and expressed the thanks of the meeting to Captain Howells for his interesting lecture.

Capt. Howells briefly replied to various points raised in the course of the discussion, agreeing as to the extreme difficulty of concealing large cities from aircraft, and discussing the appearance from above of areas of water. As regards the point raised by Mr. Walker there were various methods of stereoscopic aerial photography with which experiments had been made.

THE VISIBILITY OF AEROPLANES AND THE APPEARANCE OF OBJECTS VIEWED FROM ABOVE.

A VERY interesting contribution on the above subject, summarising work done for the Science and Research Division of the Bureau of Aircraft Production in the United States, has been recently contributed to the *Journal of the Franklin Institute** by Mr. M. Luckiesh. Objects are distinguished by differences in shade and colour, and as a preliminary to the study of this problem it was necessary to make a survey of the conditions of brightness of the earth, sea and sky. Enormous variations in these conditions are met with. The sky is a uniform background only on a cloudless day or with a completely overcast sky. Light patches of white cloud are often many times brighter than the adjacent blue sky. The average brightness of the earth, seen from above, likewise undergoes great variations according to the climatic conditions, and the time of the day and year. As data for his investigation Mr. Luckiesh commenced an investigation of eight chief factors, including the apparent reflection-factor of earth-regions and areas of water; the size of pattern for aeroplane camouflage, and various brightness measurements relating to the sky and clouds.

In the first section of his communication Mr. Luckiesh gives a detailed account of observations taken during 5,000 miles of air-travel. Diagrams are given showing how illumination due to skylight and sunlight varies with the altitude of the sun, how these factors are related to the time of day, and how illumination on a horizontal surface is received from the sky overhead. According to a well-known principle a perfectly white horizontal surface, situated at the centre of a uniformly bright hemisphere, would have the same brightness as this surrounding luminous surface. Theoretically, therefore, the upper surface of an aeroplane, if painted a dead white, might be expected to assume the same brightness as the approximately uniform sky surrounding it. But in practice the sky-surface is rarely uniform, and we have to deal with mixtures of direct sunlight and diffused skylight. Moreover, even the attainment of this exceptional condition would not help us materially towards rendering aircraft indistinguishable. An aeroplane, if viewed by a hostile scout above, is seen against the dark background of the earth; while if viewed from the ground it is seen silhouetted against the very much brighter sky above. It seems difficult, therefore, by any process to confer immunity against detection both from below and above.

Mr. Luckiesh has made a comprehensive study of the apparent brightness of landscapes seen from an aeroplane. One of the most striking things about these observations is the relatively low coefficient of reflection of such surfaces, whether ploughed fields, grass, woods, etc. Mr. Luckiesh explains this by pointing out that these irregular surfaces rarely receive the full measure of daylight illumination; therefore their coefficient of reflection appears unduly low, ranging in general between 3·5 to 10 per cent. Here are some typical figures :—

	Brightness in comparison with a perfectly white surface. Per cent.
Fields	6
Woods	4·3
Inland Water	5·5
Barren land	11·3

The low values for grass and woods are no doubt to be explained by the fact, mentioned above, that they are not plane surfaces and much of the light is smothered in the interstices between blades of grass or branches of trees. Moisture has also considerable influence—wet dirt is darker than dry earth baked by the sun.

Similar observations were made on the brightness of clouds and the effects of luminous haze. The presence of such a haze often has the effect of making the apparent brightness of landscapes greater. The results obtained for inland water were surprisingly uniform, but its brightness naturally varied much according to the

* March and April, 1919.

angle from which it was viewed. In one case, where the river was very yellow due to suspended particles of earth, an unusually high brightness was noted. When observed from directly overhead the brightness of water is due mainly to reflection of sky, and may attain 0·87 of the zenith sky-brightness.

Owing presumably to the fact that we have usually to deal with a mixture of direct sunlight and diffused skylight, and also that the apparent brightness of earth-areas is increased to some extent by the presence of luminous haze, one finds that the average brightness values, as compared with that of the zenith sky, are unexpectedly high. The following table, for example, gives the average of a number of observations, B denoting the zenith sky-brightness :—

Earth-areas—	
Woods	0·45B
Water	0·71B
Fields	0·81B
Barren land	1·14B
Landscape covered with hazy clouds	3·5 B
Cloud-areas—	
Upper sunlit sides of cumulus clouds	5·10B
Underside of massive cumulus clouds	1·4 B
Zenith Sky	B

By various calculations on specific days values for the apparent mean reflection-factor for the earth varying from 6·6 per cent. to 8·5 per cent. are recorded (the latter including the contribution to brightness of luminous haze).

From the foregoing observations it is concluded that if a perfectly white object were suspended a few thousand feet above the earth its upper surface would be 12—14 times as bright as the lower surface. The former would appear much brighter than the landscape below, and the latter (viewed from the earth) much darker than the sky above. The problem is to determine conditions which would reduce the inequality of brightness in both cases.

Taking first the problem of an aeroplane viewed from below. The brightness on the under-surfaces of the plane is derived mainly from light reflected from the earth, and Mr. Luckiesh shows that, even if perfectly white, this surface could never be expected to attain a brightness higher than 1-10th of that of a uniform sky. When viewed against bright clouds, the ratio would be very much greater, and in fact there is little help to be derived by painting the surface white. The most hopeful line of investigation for rendering the aeroplane inconspicuous would seem to be to use a translucent material for the wings of the aeroplane whereby a certain amount of transmitted light would increase the brightness of the lower surface. If fabrics could be impregnated with a liquid to render them more translucent this would be a solution, and bluish white linen or cotton fabrics used with *colourless* dopes and varnishes, would contribute considerably towards low visibility. Results obtained with a photometer on sheets of unbleached linen seem quite hopeful in this respect.

Another possible solution discussed by Mr. Luckiesh is the use of supplementary artificial light to increase the brightness of the lower side of the wings. He calculates that for an aeroplane with an under-surface of 300 square feet something like 15,000 watts would be needed to meet the conditions on a clear day. Given specially suitable atmospheric conditions, this value might conceivably be reduced considerably, but even so the difficulties of increased weight from generating apparatus, together with proper disposition of the lamps, seem insuperable.

As regards the problem of invisibility from above, conditions seem more promising. This property is chiefly valuable in making difficult the identification of planes by hostile aircraft above them. In view of the low reflecting power of the earth-surfaces (the average of which might be taken as 7 per cent.), an exceptionally dark paint would be required, but commercial black paints with a coefficient of reflection of about 3 per cent. are available. As the ground-surface above which the plane is moving constantly alters, it is impracticable to attempt camouflage-patterns similar to those used for stationary objects. Uniform colour, however, is not fully satisfactory, and a mottledone of indefinite figure seems the best com-

promise. It might be worth while also to adapt the pattern to the conditions prevailing at different times in the year. In practice it is found surprisingly difficult to locate an aeroplane specially camouflaged to suit the country over which it operates, and the fact that the view of the observer is constantly being interrupted by the wings and body of his own craft accentuates this difficulty.

The use of a dull matte coating for aircraft would also be of material value in rendering it more difficult to be picked up by searchlight beams at night. According to Mr. Luckiesh there is little to be gained by employing the principle of "confusability-camouflage" (such as is used to deceive the enemy as to the course and direction of motion of a ship) for aircraft, chiefly owing to the much higher speed at which aeroplanes travel. The use of aluminium foil is favourable to low visibility in certain circumstances, and the direct reflection of sunlight might sometimes prove inconvenient to the enemy.

THE DAZZLE PAINTING OF SHIPS.

THE "dazzle-painting" of ships, *i.e.*, the painting of their hulls in peculiar geometric patterns so as to give a misleading impression of their speed and direction of movement, was described by Lieut.-Commander Norman Wilkinson, the originator of these methods, in a recent paper before the North-East Coast Institution of Shipbuilders. The term "dazzle-painting" is not a good one as the effect does not consist in dazzling the eyes, but rather in an optical delusion; the patterns resemble more those prevailing in some futurist and cubist paintings, and the phrase "jazz-painting," humourously suggested, is perhaps more apt. Lieut.-Commander Wilkinson pointed out that an attempt to confer invisibility on ships at sea was injudicious. On land, where an object is stationary and its surroundings do not alter, it is possible to camouflage objects with fair success by painting them so as to resemble surroundings. But in the case of travelling ships at sea, where the appearance of the water and sky is constantly changing, the method is not successful. In any case a ship attacked by a submarine is seen through the periscope from close to the sea-level silhouetted against the bright sky. Colouration intended to confer invisibility is therefore of little value, and is subject to the further drawback that any delicate form of painting, besides expensive and tedious, is rapidly obscured by dust and grime.

The method adopted was therefore to divide the hull of the ship into stripes and sectors, painted with a strong, contrast in several simple colours. A ship so camouflaged may be seen with comparative ease, but by the artful use of patterns it is rendered extremely difficult to judge her speed, or even the direction in which she is proceeding. Accordingly a submarine is deceived into coming to the surface in the wrong position for delivering a torpedo, and her presence once thus revealed, the opportunity may not recur. In some cases different patterns were used on the two sides of the ship, and generally standard patterns were avoided so that no pattern could become familiar. Such methods were subsequently adopted in the United States and are also described in papers by Lieut. E. L. Warner and Lieut. H. Van Buskirk before the American Illuminating Engineering Society. An interesting feature is the description of the fully equipped small theatre with an artificial sea and sky, in which the motions and appearance of small camouflaged models could be studied.

THE THIRD ANNUAL EXHIBITION OF THE PHYSICAL AND OPTICAL SOCIETIES.

THE above exhibition, which was held at the Imperial College of Science, on January 7th–8th, contained much of interest. Mr. L. C. Martin showed the Sheringham daylight lamp (previously exhibited at the meeting of the Illuminating Engineering Society in November last). Two forms of lamps, having differently designed reflecting surfaces and respectively imitating "north skylight" and "diffused sunlight," were shown. Between them was an ordinary gas-filled lamp, working with a white reflector, enabling the difference in appearance of coloured objects illuminated by the three lamps to be clearly seen.

The Edison Swan Electric Co., Ltd., had a complete set of "Pointolite" lamps on exhibit, including the new 4,000 candle-power type, and Messrs. Newton and Co. showed several types of incandescent electric lamps suitable for lantern work, including that with the "cone" form of filament. Both exhibits were of interest as indicating possible application of glow lamps for cinema work. The Westinghouse Cooper Hewitt Co., Ltd. showed a form of quartz tube mercury vapour lamp adapted for medical purposes, the lamp being mounted in a special burnished aluminium housing.

Mr. F. Harrison Glew's demonstration of radioactive luminous materials was an interesting feature, and included samples of varying strength, small tubes used for gun-sights, painted dials for clocks, and maps of the sky with the stars traced in luminous paint, a device which has been of considerable value to troops in finding their way during night operations. Reference may also be made to a striking experiment shown by Messrs. H. Tinsley and Co., namely, the illumination of a special stroboscopic disc, attached to the rotating motor, by a neon tube. This tube was operated, through the agency of a tuning fork, at exactly 50 periods per second. The changes in appearance of the disc, with varying speed of the motor, were truly remarkable, and it was pointed out that the device could be used as one of the most sensitive methods of speed-regulation available.

Messrs. Chance Bros. and Co. showed a variety of special glasses, including some due to Sir Wm. Crookes. Special interest attaches to those designed for the transmission or absorption of ultra-violet and the uranium glass, exhibiting strong fluorescence under ultra-violet light.

The optical exhibits included many interesting forms of apparatus, amongst which the Bawtree colorimeter, exhibited by A. W. Penrose and Co., may be singled out for special mention. In this apparatus controlled quantities of coloured light passing through special filters are mixed in the form of a colour-patch. Any tint of colour may be matched by combining these elements in suitable proportions.

Restrictions of space prevent our doing more than mention a few exhibits of special interest in relation to the measurement and applications of light and colour. Much of the optical apparatus including spectroscopes, microscopes, and an ultra-condenser to facilitate the illumination of minute particles with a dark background were also worthy of study, and there was also a comprehensive display of electrical instruments.

THE BRITISH ELECTRICAL FEDERATION, LIMITED.

WE are informed that the British Electrical Federation and most of its member companies have returned from the Manchester Hotel, Aldersgate Street, to Electrical Federation Offices, 88, Kingsway (over the Holborn Station of the Piccadilly Tube Railway). As the Government has retained part of the building, the Engineering and Stores Departments of the Federation are, for the present, located in adjacent premises at 11-13, Southampton Row, while the Electrical and Industrial Investment Company and other finance companies are at 4, Broad Street Place, E.C.

SPECULAR REFLECTION FROM ROUGH SURFACES.

ALTHOUGH the conditions of reflection met with in practice with more or less rough surfaces are pretty well understood, there is much room for study in the underlying scientific facts, which might possibly lead to useful practical suggestions. The subject has recently been studied by Mr. T. K. Chinmayanandam in the *Physical Review*, the investigation being a continuation of the earlier researches by A. F. Gorton, Lord Rayleigh, T. J. Meyer and others. The subject is regarded from a wider standpoint than is necessary in illuminating engineering. For instance, lighting engineers are primarily concerned with visible light ($0{\cdot}4\mu$—$0{\cdot}75\mu$), but the range of wave lengths considered by these authors extends far into the infra-red at 14μ.

An attempt has been made to evolve a mathematical formula for such surfaces, the comparatively simple relation, $I = e^{-(8\pi^2 \cos^2\theta)/a\lambda^2}$ being attained. Here I is the intensity of the reflected radiation, a a constant depending on the nature of the surface. Values of a for four different surfaces studied by Gorton are given, and they vary considerably. It will be observed that the formula contains the wave length of light, and tables of reflection coefficients for wave lengths from 1μ to 11μ are given. Very marked differences in reflection are to be noted for different wave lengths. Speaking generally the coefficient of reflection becomes greater as we advance into the infra-red, and would ultimately approach unity. The effect of the wave length is, however, most marked when the light strikes the surface very obliquely, and several facts in explanation of this are adduced; for example, with oblique light of short wave length only the extreme outer parts of the surface come into play, whereas with rays in the advanced infra-red the parts that are deeper (in the troughs of the rugosities) are almost equally useful. These facts are interesting in relation to the reflection of heat by rough surfaces and may have a bearing on the construction of radiators. In regard to visible light it seems to be generally understood that provided the surface is *white*, there is little difference between the reflection of light of different colours at various angles.

It is to be noticed that even in this inquiry the author is brought up by the discovery that at very oblique angles his calculated formula does not apply, and he suggests a more complicated form to meet this case.

RECORDS OF LAMPS USED IN PARKS.

IN the *Electrical Review* (Chicago) Mr. C. H. Shepherd recently summarised the results of an investigation into the life of lamps used in five parks in Chicago. The record appears to have been kept in a very systematic manner, and the exact date of installation and failure of each lamp being recorded, the results are quite interesting. For outdoor lighting there were in use 1,561 400 candlepower 15 amp. lamps operated 18 in series. There are also about 300 special lamps used for lighting bathing beaches, memorials, etc., and for flood-lighting, while the indoor lighting comprised about 6,500 outlets. The record proved useful in revealing various defects in circuits that were afterwards corrected, but the most striking results relate to the effect on the life of lamps of the number of times they are switched on and off.

The lamps were run respectively on an all-night schedule (approx. 4,000 hours per year), on a half-night basis (approx. 2,200 hours per year), and alternately on the half-night and whole-night basis (equivalent to about 3,100 hours per year). The curious thing about the results, which are assembled in tabular form, is the increasing life under continued operation. Lamps installed on the same date on circuits operation for whole-night, half-night, and alternate services burned out on approximately the same date. It appears, therefore, that the number of times a lamp is turned on and off has more effect on the life than the actual number of hours burned—a curious result that should be subjected to confirmatory tests in this country.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE NEW "UKAY" INVERTED GAS LAMP.

We had recently an opportunity of viewing the new lamp of this type being manufactured by Messrs. Falk, Stadelmann and Co., Ltd., which we understand is now available for general use. The new types mark a progressive development from the original "Ukay" lamp introduced in 1910. The Bunsen tube is of the straight down type and is carried from the gas supply centrally through the lamp, and this departure from the usual bracket type of burner is considered a distinct advantage as obviating possible obstruction of the gas passage. The Bunsen tube is connected to a heavy brass cast superheater, to which the mantle nozzles are attached. (We may say that the use of substantial brass work for any parts otherwise liable to corrosion is a feature of this lamp.) All burners are simultaneously adjusted by one gas and air regulator operated from the outside of the lamp by a loose key, which can be removed to prevent subsequent interference; this appliance, and also the new frictionless gas adjuster, seem to be very simple and reliable in operation. The gas adjuster utilises two close-fitting cylindrical rods, which are gradually brought nearer together by the operation of a brass screw. There is no needle valve or small hole to clog and choke up the free gasway—in fact, any material collected should be removed by the pressure when the adjuster is screwed tight. Another feature is the simplicity

General view of the new "Ukay" Lamp.

with which the lamp can be assembled or taken apart.

Three types of lamp are being supplied: a standard type giving 150 candlepower per burner and using 1–4 burners, each consuming four cubic feet per hour; a cluster type, using 2–10 lights, working at 100 candlepower per burner and consuming approximately two cubic feet

per burner; and a high candlepower type, operating at 300 candlepower per burner and using one, two or three burners each taking approximately seven cubic feet per hour. It will be seen, therefore, that 40–50 candlepower per cubic foot of gas per hour is claimed for these lamps, a striking advance compared with the values attainable with low-pressure gas a few years ago and one not involving the complexities in lamp design which were formerly considered necessary.

OSRAM "ATMOS TYPE" LAMPS.

A leaflet issued by the General Electric Co., Ltd., gives prices and particulars of Osram "Atmos Type" (gas-filled) lamps ranging from 25 volt. 15 watt up to 200-260 volt. 1500 watt. The smaller gas-filled lamps, of which there has been a scarcity during the war, should be useful for many purposes. It is to be noted that 60 watt 100 volt. and 100 watt 260 volt. lamps are listed. As regards the high wattage lamps, which yield several thousand candlepower, these are finding ready application for streets, railways, dockyards, etc., while intermediate candlepower are suitable for the interior and exterior lighting of shops, offices, factories, hotels, etc. The leaflet also contains an illustration of the Osram-Robertson factory at Hammersmith where these lamps are manufactured.

"X-RAY" COLOUR MATCHING UNITS.

A COMPACT form of colour-matching units, issued by the National X-Ray Reflector Co. of Chicago ("Tru Da Light"), has some interesting features. It consists of a portable standard, and uses neither special coloured lamps nor diffusing plates, the white light being secured by the effect of the blue glass reflector, having a metal covering. The principle appears to be a novel one, which deserves attention in this country.

We are informed by Messrs. Watson and Sons that Mr. Howard C. Head has joined the Board of Directors. Mr. Head was formerly in charge of the Electro-Medical Department of Messrs. Siemens Bros. and Co., Ltd., and has a long experience of X-Ray work dating back to 1896.

THE METRIC SYSTEM AND PUBLICITY LITERATURE.

In view of the great impetus that has been given to the metric system during recent years, and the important part which a knowledge of the system will play in the European trade of the future, there is every reason to make the system more familiar and to render the conversion from British to metric measures easier.

One of the readiest means of accomplishing this is undoubtedly the inclusion of metric measurements in catalogues and it has been suggested that for the present both the British and the metric equivalent should be given side by side. We are interested to observe that this practice has been adopted in a recent catalogue on Lanterns and Reflectors issued by the Wardle Engineering Co., Ltd., of Manchester. Dimensions and weights are given in both systems and we hope that this enterprising step will be adopted by other makers of lamps and lighting accessories.

A NEW YEAR'S RESOLUTION.

A LEAFLET, being distributed by The Benjamin Electric, Ltd., bearing the above title, emphasises that every lamp installed should be provided with the appropriate reflector, Benjamin reflectors being available for every class of installation. Attention is drawn to the new catalogue entitled "Cause and Effect," which was recently the subject of comment in these columns.

STREET LIGHTING IN HACKNEY.

WE are informed that 400 B.T.-H. "Effracta" lanterns have been lately installed for the street-lighting of Hackney and that ultimately there will be in use 500 of these units. The B.T.-H. "Effracta" lantern was described in these columns some time ago. Readers will recall that it utilises a special prismatic glass bowl-refractor whereby the light-rays are redirected at an angle slightly below the horizontal (the maximum intensity being at 85° with the vertical), thus securing the requisite distribution of light favourable to uniform illumination. The refractor consists of two parts, one fitting inside the other, both the inner and outer surfaces being smooth and easily cleaned. An adjustment, enabling the lamp filament to be brought into correct focus, is provided.

PAINT AND ILLUMINATION.

THE important part played by paint in relation to the lighting of interiors is apt to be overlooked. In the case of indirect and semi-indirect installations the influence of light surroundings is naturally of special importance, and in some cases the illumination on the working plane may be increased 200 per cent. or more simply by refinishing, with a good quality paint of light tint, ceilings which have been allowed to become discoloured or dirty. In all lighting installations, however, the effect of light surroundings in increasing the working illumination is more or less marked, and materially influences the "co-efficient of utilisation" (*i.e.*, the percentage of the total light from the lamps installed received on the working area). But apart from this increase in illumination the appearance of illuminated objects should be considered. A desk covered with a black surface, for example, appears a badly lighted object, because it reflects little light, even though it may be receiving quite a high illumination in foot-candles. A room papered in light materials appears much better lighted and gives a more cheerful effect than one covered with dark materials absorbing 70 per cent. or more of the light they receive.

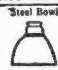
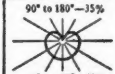
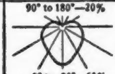
Reflection Factor		Ceiling	Light 70%		
		Walls	Light 50%	Medium 35%	Dark 20%
Reflector Type	Light Output	Ratio = Room Width / Ceiling Height			
Prismatic Glass  Bowl-Frosted Lamp	90° to 180°—22%  0° to 90°—65%	1	.42	.38	.35
		1½	.50	.46	.43
		2	.56	.52	.49
		3	.63	.59	.55
		5	.70	.66	.63
Dense Opal  Bowl-Frosted Lamp	90° to 180°—20%  0° to 90°—60%	1	.41	.37	.34
		1½	.49	.45	.42
		2	.54	.50	.47
		3	.60	.56	.53
		5	.67	.63	.59
Steel Bowl  Porcelain Enameled	90° to 180°— 0%  0° to 90°—65%	1.	.38	.36	.34
		1½	.45	.43	.41
		2	.49	.47	.45
		3	.54	.52	.50
		5	.59	.57	.55
Indirect  Mirrored Glass	90° to 180°—80%  0° to 90°— 0%	1	22		
		1½	.27	.24	.22
		2	.31	.28	.26
		3	.36	.33	.31
		5	.42	.39	.37
Semi-Indirect  Light Opal	90° to 180°—60%  0° to 90°—25%	1	.27	.24	.21
		1½	.34	.30	.27
		2	.39	.35	.32
		3	.45	.41	.38
		5	.51	.47	.44
Enclosing  Light Opal	90° to 180°—35%  0° to 90°—40%	1	.23	.20	.17
		1½	.30	.26	.23
		2	.35	.31	.28
		3	.41	.37	.34
		5	.48	.44	.41
Semi-Enclosing  Opal Bowl	90° to 180°—20%  0° to 90°—60%	1	.32	.28	.26
		1½	.40	.36	.33
		2	.45	.41	.38
		3	.52	.47	.44
		5	.59	.54	.51

Table of Co-efficients of Utilisation. (From the B.T.-H. Incandescent Electric Lamp Handbook, No. 1A).

Yet another factor influenced by the nature of surroundings is the diffusion of light. Good diffusion and soft shadows are the result of light coming from a number of different directions and from a relatively large illuminated surface. If the walls and ceiling are light in tint satisfactory diffusion may often be obtained from a single unit, whereas in dark surroundings it could only be obtained with difficulty by using a number of closely spaced lamps.

The "co-efficient of utilisation" defined above is a factor of great importance in designing lighting installations, and it is interesting to note that the Illuminating Engineering Department of the British Thomson-Houston Co., Ltd., have published, in tabular form, a series of data enabling such co-efficients to be determined, having due regard to the nature of the lighting installation, the colour of surroundings and the dimensions of the interior. Inquiries on this matter should be addressed to the British Thomson-Houston Co., Ltd., at Rugby, or at 77, Upper Thames Street, London, E.C.4.

PUBLICATIONS RECEIVED.

Good Lighting as an Aid to "Safety."

A TECHNICAL pamphlet by Mr. L. Gaster, recently issued by the British Industrial "Safety First" Association under the above title, contains some readable notes on industrial lighting in relation to health and safety. Instances of accidents caused by defective lighting are given, and the value of good illumination in relation to health and efficiency is illustrated by practical examples. The latter half of the booklet contains some general notes on the fundamental principles of lighting and the measures necessary to obtain it. A feature of the pamphlet is the liberal use of illustrations. Copies may be obtained (price sixpence) on application to the British Industrial "Safety First" Association, 2-3, The Sanctuary, Westminster, S.W.1

The Electrical Engineer's Diary. (S. Davis and Co., London, 1920. pp. 474.)

THE ELECTRICAL ENGINEER'S DIARY is so well known to our readers that there is little to say regarding the 1920 issue, except that it is fully up to the level of preceding issues. It will be recalled that illumination is dealt with in a special section, an important feature being the treatment of industrial lighting. There are also notes on street-lighting, car-lighting, and searchlight projectors. In the various sections dealing with electric power we have again the method of division, enabling the needs of various industrial processes, mills, etc., to be quickly grasped while the general information on electric supply, including a list of streets served by various companies, is not the least useful item in the diary.

Electrical Development Association Bulletins.

WE have received from the Electrical Development Association (Hampden House, Kingsway, London, W.C.), a series of recently issued bulletins, illustrating the various applications of electricity in daily life. Of chief interest is a pamphlet illustrating attractive methods of using electricity for shop-lighting, and we are glad to see that stress is laid on the proper use of lamps in lighting shop-windows, the lighting being concentrated on the goods instead of escaping out of the window to dazzle the customers' eyes.

Co-partnership Souvenir of the Great War.

THE CO-PARTNERSHIP JOURNAL has issued a special January number commemorating the part played by members of the South Metropolitan Gas Company in the great War. A well-illustrated series of articles deal with the many applications of gas and by-products of the gas industry for war purposes, special attention being devoted to chemical activities at the important works at East Greenwich. Another article gives a record of the company's fleet, a number of vessels of which were unfortunately lost, while others had exciting experiences. Lists of the members of the company who gained distinctions on service and of the fallen are appended. Finally, we may mention the short article entitled "After the War," in which a co-partner gives his impressions and emphasises the important part to be played by co-partnership in the scheme of reconstruction.

American Journalists in Europe. By H. M. Swetland. (Published by the United Publishers' Corporation, New York.)

WE have received an admirably printed and illustrated volume by Mr. H. M. Swetland (President of the United Publishers' Corporation, New York), which is intended to serve as a permanent record of the visit of the American industrial technical journalists to England and France as guests of the Ministry of Information. A full account is given of the experiences of the party when studying industries in England and France, and in the war-area, and of the various functions which they attended. A report of the meeting arranged by the Circle of Scientific, Technical and Trade Journalists at the Stationers' Hall on December 18th, 1918, is also included.* British journalists will cordially reciprocate the desire expressed for closer co-operation between the technical press in both countries.

* ILLUMINATING ENGINEER, Dec., 1918, p. 279.

INDEX, January, 1920.

A Study of the Performance of "Night-Glasses," by L. C. Martin (Lecturer in Technical Optics, Imperial College of Science and Technology), issued by the Department of Scientific and Industrial Research, 15, Gt. George Street, Westminster, S.W.1.

DR. MARTIN'S research is one of the fruits of the newly established Technical Optics Department at the Imperial College of Science and Technology. It has long been known that some forms of telescopes give enhanced visibility at night (in spite of the facts that the brightness of the image can never exceed that of the object, and that there is necessarily absorption of light in the telescope). Dr. Martin has attempted a study of the various factors which affect the problem, which include the size of the retinal image, its definition, size and brightness, and the sensitiveness of the eye. A relation is given for the brightness of the image and various diagrams illustrate connection with illumination and angular subtense, duration of impression, etc.; the effect of area of background and condition of eye are also studied. A considerable number of useful conclusions are drawn. In practice a compromise between different factors is often necessary, but in general a power of 5–6 with the largest field of view possible and an exit-pupil of 7–8 mm. seem desirable in a hand instrument for night use. For stand instruments more latitude can be allowed and a magnifying power of 10 or more may sometimes be used with advantage. The question is of considerable importance in relation to stand telescopes for use in night artillery work. The essence of the problem is succinctly summarised in an introductory note by the Director of the Department, Mr. F. J. Cheshire.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

A BULLETIN recently issued by the above Department contains a list of Research Associations which have been approved by the Department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. Thirteen such associations have been actually formed, and we observe that the list includes associations dealing respectively with scientific instruments and with glass research. There are also four other research associations approved by the Department, but not yet licensed, three others (including the British Electrical and Allied Industries Research Association), whose articles of association are under consideration, and three more whose memorandum and articles of association are now being prepared.

RESEARCH ASSOCIATION OF THE BRITISH LAUNDERS' INDUSTRY.

WE understand that the above Research Association has been approved by the Department for Scientific and Industrial Research as complying with the conditions laid down by the Government scheme for the encouragement of industrial research. The Secretary of the Committee engaged in the establishment of this Association is Mr. J. J. Stark, 162-5, Bank Chambers, 329, High Holborn, W.C.2.

VOLUMETRIC TESTING OF SCIENTIFIC GLASSWARE AT THE NATIONAL PHYSICAL LABORATORY.

THE manufacture of volumetric scientific glassware, *i.e.*, burettes, pipettes, etc., is an industry which was practically non-existent in this country before the war, but has since been developed. In order to maintain the position in this respect, accuracy in manufacture is of great importance, and manufacturers have now available at the National Physical Laboratory facilities for testing such accuracy on a scientific basis. Work on a small scale has been done for the past fifteen years, but a new building has just been completed at the Laboratory specially equipped for this purpose, which will doubtless enable operations to be considerably extended.

Full particulars may be obtained on application to the Director, The National Physical Laboratory, Teddington.

BRITISH INDUSTRIAL "SAFETY FIRST" ASSOCIATION.

ACCIDENT PREVENTION GALLANT CONDUCT AWARD.

WE observe that the British Industrial "Safety First" Association has instituted an Accident Prevention Gallant Conduct Award, in order to recognise conspicuous acts of gallantry performed in the prevention of industrial accidents by employees of members of the Association. The award consists of a silver medal with badge attached. Recommendations should be addressed to the offices of the Association (2-3, The Sanctuary, Westminster, S.W.1.).

FIRST GENERAL MEETING.

The First General Meeting of the British Industrial "Safety First" Association is being held, by the courtesy of the Rt. Hon. the Lord Mayor (Sir E. E. Cooper), at the Mansion House on the afternoon of February 24th, and will be followed by a Dinner at the Cafe Monico, at both of which Lord Leverhulme will preside.

Readers will join us in wishing prosperity to the Association on the occasion of their first annual gathering, and continued success in the good work in which it is engaged.

SOME ATTRACTIVE SUBJECTS FOR POPULAR LECTURES.

THE popular lecture is undoubtedly capable of much fuller development than in the past, and at the present time it has perhaps better possibilities than for many years past. We notice that Mr. J. P. Maginnis has prepared a series on a variety of interesting subjects, on which he has special knowledge, and is prepared to arrange dates with secretaries of societies, college principals, public schools and others interested. The lectures are all fully illustrated by lantern slides.

Among other subjects the history of the manufacture of writing implements, steel pens, reservoir, stylographic and fountain pens, sewing needles, pins, and lead pencils are mentioned. Dates are now being arranged for a popular historical lecture entitled, "When Royalty dwelt in the Strand." Those interested should apply to Mr. J. P. Maginnis, 11, Carteret Street, Westminster, S.W.1.

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ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

OFFICIAL ORGAN OF THE

Illuminating Engineering Society.

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EDITORIAL.

Colour-Matching by Natural and Artificial Light.

The effect of light of different colours on the appearance of objects of different hue, and the problem of imitating artificially the tint of normal daylight, has been discussed before the Illuminating Engineering Society on several occasions in the past—for example, in the discussion on Colour-Discrimination by Artificial Light opened by Mr. T. E. Ritchie in 1912, and again in the discussion on the Lighting of Picture Galleries opened by Professor Silvanus P. Thompson in 1914. The former meeting was also notable for the exhibition of the special colour-matching unit, involving the application of a combination glass and tinted gelatine screen with an ordinary vacuum tungsten lamp, by Dr. Kenneth Mees. We believe that this was the first occasion on which a device intended to produce "artificial daylight" from an incandescent electric lamp was shown in this country, although Professor Gardner had already produced a screen of this nature for use with the arc lamp. Progress in this field was recently summarised by Mr. A. P. Trotter in an able contribution to the *Times Engineering Supplement*, which has been dealt with in this journal.*

Since the date of these discussions before the Illuminating Engineering Society a considerable amount of work on artificial daylight has been done. Mr. L. C. Martin, in his paper before the Society on Jan. 27th, explained in

* ILLUMINATING ENGINEER, December, 1919.

detail the investigations leading to the development of the "Sheringham" daylight device. He also reviewed the principles underlying the appearance of colours by natural and artificial light, and the various methods of imitating daylight artificially. Valuable supplementary contributions to the discussion by Mr. M. Luckiesh and Mr. N. Macbeth summarise developments in the United States, where great progress in the practical use of "artificial daylight" units employing special tinted glass with tungsten lamps has been made.

The "Sheringham Daylight" is interesting as the result of the combined work of a physicist, Mr. L. C. Martin, an artist, Mr. G. Sheringham, and an expert on camouflage problems, Major Klein. The method employed, i.e., the specific colouration of light by *reflection* from a surface covered by a pattern of selected hues, marks a departure from the practice almost invariably used by other investigators, namely, the use of a tinted glass or gelatine screen with a view to effecting the desired change in spectrum by *transmission*. According to Mr. Martin, the efficiency obtainable when a gas-filled lamp is used and when the same variety of daylight is imitated is not widely different in the two cases. The fact of the light being diffused from a relatively large surface is considered an advantage, and Mr. Martin and his co-workers have evidently taken special pains to secure permanent colours, such as will not readily fade. It was, however, suggested in the discussion that in course of time the reflecting surface might be affected by ageing through deposits of dust, etc., and no doubt this requires to be guarded against.

One point very strikingly brought out by Mr. Martin is the variations that occur in the colour of daylight itself. Direct sunlight, diffused daylight from a white sky, and blue skylight are by no means the same, and the exact imitation of the latter involves greater difficulty and some sacrifice of efficiency. In view of these variations it may well be, as suggested by Mr. Trotter in the discussion, that for most ordinary purposes it is unnecessary to aim at very great accuracy, with the difficulties and loss of efficiency it entails, although for very careful colour-matching work a close resemblance to normal daylight is doubtless necessary.

In order that the whole subject may be placed upon a scientific footing it appears essential that a standard of "Normal" daylight should be defined, and the degree of accuracy with which "Artificial daylight" units for various purposes should approach this standard specified. We should also like to see a systematic comparison of the various systems of artificial daylight available, with a view to ascertaining the varieties of work for which each is most suitable.

Agreement is also desirable on a standard white surface, and a corresponding system of colour-tints, to which standard nomenclature should be applied. Such a series of colours would form a necessary groundwork of proper scientific treatment of colour-problems. There are already in existence several series of tints, but those used in various industries are by no means identical. One of the most complete of these is the series prepared by the Société des Chrysanthémistes in France, bearing names of colours in four languages (English, French, German and Spanish).

The problems outlined above are complex and naturally not so easily solved. But there is no reason why this should not be done in course of time, and the Illuminating Engineering Society would gladly co-operate with those industries interested (such as those concerned with dyeing and textile operations) in researches in this direction.

Apparatus for the Analysis and Study of Colour.

Closely allied to the problems of designing lamps and lighting appliances for colour-matching purposes is that of devising apparatus for the study of coloured surfaces. This was dealt with in some detail in the discussion before the Illuminating Engineering Society in 1912, but there have since been various forms of new or improved apparatus and methods devised. Apparatus of this kind is primarily intended to enable any desired colour to be imitated or reproduced ; or it may serve the purpose of ascertaining how closely two sources approach each other as regards the colour of their light by analysis of their spectra. There are also various subsidiary methods by which indirect inferences regarding colour-revealing properties may be drawn.

The two forms of apparatus shown at the meeting of the Illuminating Engineering Society aimed at the imitation of coloured surfaces. The well-known "Tintometer" achieves this by the combination of a wide range of glasses of various tints by the aid of which any desired hue may be matched and subsequently reproduced. In the colorimeter shown by Mr. Bawtree the method of combining, in suitable proportions, the light transmitted several gelatines of standard colours, so as to form a composite colour-patch, was adopted. In this case a gas-filled lamp was used, and one would imagine that the choice and control of this lamp would be of some importance for accurate work, as variations in voltage, or ageing of the lamp might influence the colour of its light.

In order to make a comparison between artificial and natural daylight we may rely upon the appearance of delicate colours placed side by side and illuminated by the two sources. As Mr. Trotter remarked in the discussion, it is important that there should be only a fine line of division between the two areas compared—a principle which is also the key to success in photometry. For a very accurate comparison it is doubtful if there is any apparatus that exceeds in refinement the spectrophotometer, although much valuable information can be gained by a study of the distribution of radiation in the spectrum by the thermopile or similar means. This, however, is essentially a laboratory method, requiring skilful application.

Other supplementary methods include the examination of the amount of light reflected by a series of coloured surfaces respectively by natural and artificial light. Any marked variation in the percentages of reflected light would be considered evidence of a departure from the spectrum of natural light. Yet another method, which, however, admittedly presents great difficulties, is the use of photographs with special panchromatic plates.

On the whole it may be said that much remains to be done before we can present an absolutely reliable, simple and inexpensive apparatus for testing colours. With the growth of interest in these problems there should be a demand for such apparatus, which may lead to developments towards simplicity, similar to those that have taken place in illumination photometers. But, just as in judging the brightness of illuminants, we shall always have to interpret the records of instruments with reference to the impressions received by the eye, and in this field, too, there is much to be done in studying the differences in the colour-vision of the individual, and the manner in which judgment may be affected by other adjacent coloured surfaces by the past history of the eye, and other factors.

The Care of the Printer's Eyesight.

A recent issue of the *Dioptric Bulletin* contains a summary of the lecture delivered by Mr. J. H. Sutcliffe on the above subject in December last, forming one of the St. Bride Foundation Printing School monthly lectures. As Superintendent of the Army Spectacle Depôt, Mr. Sutcliffe has had special opportunities of observing the conditions of eyesight of large masses of men, and his acquaintance with printing processes enabled him to enter fully into the requirements of the compositor.

Speaking of his work in connection with the Army Spectacle Depôt, Mr. Sutcliffe said it had been found that as many as 350,000 men in the new army were in actual need of glasses. To the printer eyesight was of vital importance; he might have other defects and yet do his work well, but if his eyesight failed his livelihood was gone. He suggested that all those entering the trade should have their eyes tested, both for acuteness and colour-perception. Thus slight defects and tendencies, which might afterwards prove a serious handicap, could be detected in time.

In the course of the discussion some reference was made to lighting problems, though we should like to have heard more of the views of printers on this subject, seeing that lighting has so much to do with the care of the eyes. It was suggested, however, that both general and local lighting had their proper sphere. A method of mounting the lamps inside cases set above the compositor's racks, so that the light was completely screened from the eyes of the worker, was spoken of with approval, and reference was also made to the value of artificial daylight units for colour-printing work. Mr. Sutcliffe recommended the practice, common in American printing works, of using small green celluloid screens attached to the forehead to shade the eyes. Speaking generally, one might say that a system of lighting which makes the use of such shades necessary would be an imperfect one, as the presence of some degree of glare is implied. On the other hand the nature of the occupation needs to be considered. Eyes that have become fatigued are highly sensitive to light, and may find glare in conditions quite agreeable for less arduous work. The use of eye-shades by people engaged on work that is very trying to the eyes deserves notice, and it is common experience that in such cases relief is afforded by shading the eyes with the hand. The effect may be a matter of contrast, and the point is one that deserves study by physiologists.

Another point strongly emphasised by the lecturer was the choice of a good type, easily read. In the interests of vision we think that a limit might well be set to the smallness of type used for printed matter. We are aware that conditions of economy may be considered to justify such small type in some cases; but anything which is worth printing should be set in type that is clearly legible, and does not involve eyestrain. Mr. Sutcliffe contended that newspaper proprietors would find it to their interest to use a good bold type and the whitest non-glossy paper, as the ease with which a paper could be read had a great influence on the choice of a newspaper by the public. The selection of type was not merely a matter of size. Most English readers would find the longer type used in French newspapers trying, and it was well known that the Gothic characters formerly in general use in Germany were also prejudicial to eyesight.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

COLOUR-MATCHING BY NATURAL AND ARTIFICIAL LIGHT.

(Proceedings at a meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m. on Tuesday, January 27th, 1920).

A MEETING of the Society was held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, January 27th, THE PRESIDENT (Mr. A. P. TROTTER) in the Chair.

The minutes of the last meeting having been taken as read the Hon. Secretary read out the names of new applicants for membership as follows :—

The names of applicants announced at the last meeting of the Society* were read for the second time and these applicants were formally declared members of the Society. The HON. SECRETARY, in referring to the nomination of Dr. G. YAMAKAWA, the first President of the Japanese Illuminating Engineering Society, as an honorary member, expressed the hope that there would be

Ordinary Members :—

Carey, H. J. P.	Assistant, City of Birmingham Electric Supply Department.
Fletcher, G. K.	Technical Assistant to Consulting Engineer, 73, Duke Street, Darlington.
Gibson, H. C.	Electrical Engineer, Oldestede, W. Sittingbourne.
Mitton, A. F.	Engineer, Carlton Buildings, 35, Paradise Street, Birmingham.
Ottewell, B.	Illuminating Engineering Department, British Thomson-Houston Co., Ltd., Birmingham.
Wyatt, A. W.	Engineer, The Stock Exchange, London.

Associates :—

Llewellyn, Dr. T. Lister, M.D.	Medical Inspector, 35, London Road, Newcastle, Staffs.
Souter, Dr. W. C., M.D.	Physician, 2, Bon Accord, Aberdeen.
Wilson, H. C.	Student, Faraday House.

* ILLUM. ENG., Jan. 1920, p. 5.

many opportunities for fruitful co-operation between the two bodies.

The PRESIDENT then called upon Mr. L. C. MARTIN, of the Imperial College of Science, to read his paper on **"Colour-Matching by Natural and Artificial Light."** The early part of the paper, which was illustrated by lantern slides, was devoted to a discussion of the various factors affecting the appearance of coloured surfaces, and an analysis of the spectrum distribution of various illuminants. The author then proceeded to summarise the different attempts to produce "Artificial Daylight." He concluded by a full account of the Sheringham Daylight, which was exhibited, types of shades suitable both for a blue skylight and for diffused sunlight being shown.

The HON. ASSISTANT SECRETARY (Mr. J. S. Dow) then presented two written communications to the discussion from Professor W. GARDNER, of the Bradford Technical College, and Mr. M. LUCKIESH of the N.E.L.A. works at Cleveland, U.S.A. Professor GARDNER described the form of arc lamp, equipped with a special colour-screen, and devised by him for colour-matching work many years ago, and Mr. LUCKIESH gave an account, illustrated by photographs, showing the development of artificial daylight units in the United States.

Mr. A. E. BAWTREE described a form of colorimeter, by the aid of which any colour-tint could be matched by a combination of red, green and blue light, obtained by transmission in specified proportions of light through tinted gelatines. Miss F. E. BAKER showed a form of lamp devised for use with Lovibond's Tintometer, and also a portable form of tintometer apparatus. Mr. G. HERBERT exhibited the form of daylight unit first shown before the Society by Dr. K. Mees in 1912.

The discussion was of a varied nature, the PRESIDENT mentioning that invitations to be present had been extended to members of the Textile Institute, the Society of Dyers and Colourists, and the Paint and Varnish Society. In the discussion Mr. A. S. JENNINGS, Dr. J. F. CROWLEY, Mr. R. SUTCLIFFE, Mr. W. WALLACE, Mr. F. E. LAMPLOUGH, Mr. L. GASTER, Mr. G. SHERINGHAM and the PRESIDENT took part, and Mr. Martin briefly replied to the various comments.

A vote of thanks to Mr. MARTIN and the other exhibitors concluded the proceedings, the PRESIDENT announcing that the **next meeting** would be held at **8 p.m.** on **Tuesday, February 24th,** when a discussion on **"Illumination in Mines, with special reference to the Eyesight of Miners"** would be opened by Dr. T. LISTER LLEWELYN.

Obituary.

COMM. ING. LUIGI PONTIGGIA.

WE learn with great regret of the recent death of Sig. (Comm. Ing.) Luigi Pontiggia, the Director of the Association for the Prevention of Industrial Accidents (Associazione degli Industriali d'Italia per Prevenire gli Infortuni del Lavoro) in Milan. Under the guidance of Sig. Pontiggia the Association has done most valuable work in this field, and he has been largely responsible for the interest taken in these matters in Italy.

Sig. L. Pontiggia was also the acting President of the First Congress for the Prevention of Industrial Accidents, which took place in Milan in May, 1912, and at which the importance of good illumination, in the interests of health and safety, was strongly emphasised, several papers being read on the subject. Subsequent to the Congress, at which the Illuminating Engineering Society was represented, Sig. Pontiggia was nominated an Honorary Member of the Society, in which he took a sympathetic interest, as in all movements concerned with industrial hygiene and the prevention of accidents in factories.

COLOUR-MATCHING BY NATURAL AND ARTIFICIAL LIGHT.

By L. C. Martin, D.I.C., A.R.C.S., B.Sc.

(*Lecturer in the Optical Engineering Department of the Imperial College of Science and Technology.*)

(Paper delivered at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, January 27th, 1920.)

(1) The Nature of Light and Colour.

A considerable amount of literature dealing with this and allied subjects is now available, and it is not too much to say that the whole subject of the production of "artificial daylight" has been placed on a comparatively well recognised quantitative basis. For a very convenient summary the chapter on "Colour in Lighting" in Luckiesh's admirable book on Colour may be consulted. It may not be out of place however to summarise some of the main points, using throughout the terminology of the wave theory of light.

To begin with then, colour is a human experience which is produced by the effects of light on the eyes. We are accustomed to speak of the light derived from some very hot bodies (such as the sun) as white. Such white light may be "dispersed" by refraction or diffraction when effects of colour are produced. By optical means the coloured lights may be recombined, and the resultant light gives the sensation of white. If however any considerable part of the coloured components is removed and prevented from recombining with the rest, the resultant will no longer appear white, but will be of a colour which is called "complementary" to the remainder now absent. Objects in the world around us are seen by their reflection, scattering, and transmission of light, and almost always this is accompanied by the loss of some of the components of the light, the remainder which reaches the eye then possessing the characteristic appearance known as colour. The fine particles in the upper atmosphere respond to the light and become themselves new sources of radiation: but this response is smaller in the red end of the spectrum, so that a greater proportion of the red components of the light travel outwards into space and are lost, while an amount of light becoming greater with decreasing wave length is returned from these particles, giving the appearance of the blue of the sky. An imitation of this effect can easily be made experimentally by the scattering of light from fine precipitates, thus providing the most obvious means of obtaining an artificial daylight. We must not forget that it is the *brain* which sees, and that colour perception and recognition is very largely a matter of practice, needing special training. Few persons realise the tremendous differences in colour produced by the change from blue sky light to sunlight which is so commonly seen in the shadows on a sunny day. To a large extent the colour interpretation of an untrained observer is a matter of self suggestion, hence the method of recognising colours in a landscape by looking at them through a small hole in a screen, so that the artist forgetting what it *is* that he sees may come to some approximation of its true appearance.

Thus it is that the light of artificial illuminants generally gives the sensation

of whiteness. It is not until they are seen in simultaneous contrast with sunlight or skylight that their colour is noticed. At this stage it may be useful to study the physical differences in the spectra of various illuminants, as far as energy distribution is concerned. The effects of increasing the temperature on the spectrum of a "black body" or perfect radiator have been studied by Lummer and Kurlbaum. They have shown that the position of maximum energy in the spectrum tends to shift into the regions of shorter wave lengths as the temperature rises. The radiation of the sun corresponds approximately to that from a black body at 5000° C., a temperature at present impossible on the earth in any of our artificial illuminants. Certain substances however possess the property of radiating a greater proportion of energy in the shorter wave lengths than would be emitted by a perfect radiator. Thus in spite of the fact that the temperature of an incandescent gas mantle is not very high (comparatively speaking) mantles of certain composition radiate a light which appears green or blue compared to the light from other artificial sources, and I have been told that incandescent gas is more satisfactory for painting at night than electric lamps.

Naturally any increase of temperature

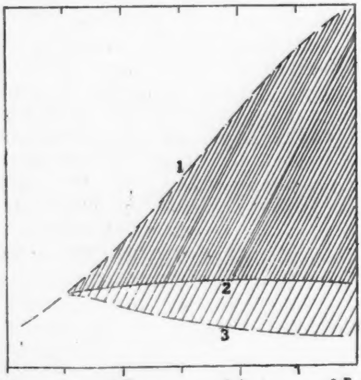


FIG. 1.—Distribution of Energy.
(1) Gas-filled lamp. (2) Sunlight.
(3) Blue Skylight.

of the sources brings the energy distribution nearer to that of sunlight. Fig. 1 is founded on data quoted by Luckiesh. The curves for clear noon sunlight and blue skylight are shown and were obtained by Ives as the weighted mean of the results of several observers. The figures apparently apply to light reaching the earth's surface after passing through the minimum possible thickness of atmosphere, but the effects of an oblique path and increased thickness will be greatly to modify the relative intensities of the various wave lengths in sunlight as well as the apparent intensity of the light itself. Abney gives interesting data calculated on the basis of Lord Rayleigh's formula for the intensity of the scattered light

$$I' = I e^{-n\lambda^4}$$

where I' and I are the intensities of the scattered and incident light respectively. He has found by experiment that the index n is proportional to the barometric pressure.

If sunlight varies it follows that its complement must vary also: thus it seems clear that it is very difficult to forecast the energy distribution at any particular time. The effects of daylight are complicated also by reflection from, and transmission through clouds and naturally such effects are quite outside the possibilities of standardisation.

While the foregoing remarks are quite true it is nevertheless the case that certain broad distinctions remain. Thus in the light from a north window, provided that fogs or pink clouds, etc. are absent, the distribution of energy will probably lie somewhere between that of sunlight and blue sky, as shown in the diagram. As a result general observation the energy intensity of the blue will at least be greater than that of the red, and sometimes about two to three times as much. This appears from the work of Nichols.*

A glance at the curves for other artificial sources reveals enormous differences from daylight. The intensity maximum generally lies far in the infrared and it is only the effect of the eye which produces an apparent whiteness of the light. In spite of the discrepancies of the energy distribution the maximum

* Phys. Rev., Vols. 26 and 28. Nichols finds that many overcast skies differ little from blue skies in the quality of the light.

visual luminosity for ordinary sources of light is generally confined to a comparatively narrow region of the spectrum. Also when the eye is accustomed to a particular light it tends to receive an increasing impression of whiteness, such an effect being familiar to persons using a ruby lamp. The consciousness of the extreme "redness" of the light diminishes. With increasing intensity of a coloured light also the sensation of colour diminishes, the general effect tending to whiteness.

(2) Coloured objects, and effects of different illuminants.

It is common knowledge that all colours with the exception of the purples are found in the spectrum, different effects being produced by dilution with white and varying the intensity. The purples are produced by the combination of red and blue light: these must be distinguished from spectral violet, which can, of course, be matched by red and blue, but which is itself a homogenous radiation. In the great majority of cases the absorption or reflection spectra of coloured objects are comparatively simple. In the case of colours seen by reflected light (the most usual case) the light often penetrates into the surface layers of the material, thus undergoing absorption effects, with the exception of a smaller and varying amount of which does not penetrate at all, and may undergo diffuse or specular reflection according to the state of the surface. Sometimes the light penetrates through a layer of absorbing matter before being reflected at an interior white surface as in the case of a thin layer of pigment or dye coated upon white paper. In the case of solid pigments, however, the colour is mainly produced by the surface layers of the pigment grains. A great deal of work on the absorption spectra of various dyes has been performed, and results have been published notably by Uhler and Wood and by Mees. In a great number of cases the material transmits but a narrow range of the spectrum, and if this is so no great change in the colour of the object is to be anticipated when the illuminant is changed, although the "value" or brightness of the colour may alter, as the wave length of light is not altered by transmission.

Take, however, the case of a purple material which reflects blue and red equally well. Light from a north window may give rise to a reflected light from the purple containing blue and red in the proportion of two to one, whereas when a gas-filled tungsten lamp is employed the proportions may change to two to six, thus producing the reddish appearance so common to violets and purples under artificial light. Generally speaking, the most violent changes are found in materials which produce their effects subjectively by the union of two or three parts of the spectrum, other parts being missing, or of low intensity.

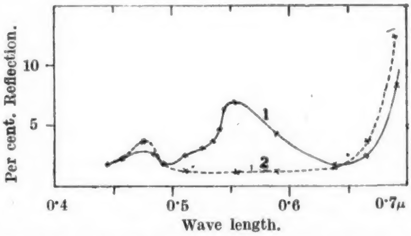


FIG. 2.—Showing Spectral Reflection of two special fabrics, (1) and (2).

Fig. 2 shows the spectral reflection coefficients of two coloured fabrics which exhibit extraordinary changes under artificial light as compared to daylight. I am indebted to Mr. Walker, of Messrs. Eastman, Ltd., for the loan of these fabrics for measurement. The curves were obtained by means of Abney's colour patch apparatus.

(1) is dyed with Benzyl Violet 5 B.N. and Quinoline Yellow, and in blue sky light it is of a moss green colour but in artificial light it becomes quite brown.

(2) is dyed with Benzyl Violet 5BN, Formyl Violet 10B, and Quinoline Yellow; in blue skylight it matches fairly well with a very dark navy blue, although a suggestion of a warmer tinge is present. In artificial light it is quite a dull red in colour.

The reason for these changes will be understood when the curves are studied. As a matter of fact these fabrics exhibit a kind of intermediate effect when viewed

in sunlight (in winter sunlight at least), and the slightest suggestion of a fog will cause colours like No. 2 to change their hue to the eye.

I am also indebted to Mr. Wilkinson of the Bradford Dyers' Association, Ltd., for a selection of fabrics dyed with somewhat similar combinations, which exhibit violent changes from daylight to artificial light. When examining some such sensitive tests the effect of the "yellow spot" of the eye is often extremely marked. This pigmentation of the "macula lutea" causes an effect similar to a local illumination of the object by artificial light immediately at the point under examination A darker patch seems to follow the point at which vision is directed, the remainder of the fabric appearing quite different in colour. Colour matching under such conditions is extremely difficult.

In passing it occurs to me to suggest that this pigmentation of the macula lutea is really for the purpose of sharpening up the retinal image which otherwise would show quite noticeable amounts of blue and violet haze owing to the well-known chromatic aberrations of the eye.

Fabrics such as these are extraordinarily sensitive tests of artificial illuminants intended to represent daylight, and for such I believe the presence of spectral violet to be of importance.

Generally speaking there is a curiously unsatisfactory appearance even in "strong" colours under artificial light (except the reds). Beyond the colour distortion there is an effect of curious weakness which is explained by the surface reflection previously noted. This reflected light, which undergoes no colour modification, is strong in comparison with the weak light which actually undergoes transmission in the surface layers of the object. Absence of violet in an artificial daylight gives such a flat appearance to violet fabrics, though the colour may be correctly rendered.

(3) Production of Artificial Daylight from Gas-filled Lamps.

As the subject has been treated fairly fully by Luckiesh, little need be said here. Fig. 1 shows the energy distribution in the spectrum of the light, and the shaded portions represent the amounts which must be absorbed or removed from the longer wave lengths in order to produce a relative energy distribution similar to that in blue sky light and in sunlight. The transmission factors of absorption screens or the reflection coefficients of ideal reflectors to produce the necessary correction are easily calculated. As for "luminous efficiencies" where the correction commences at $0{\cdot}45\mu$ the transmission efficiency considered alone is reduced to 33 per cent. for sunlight and 19 per cent. for blue sky light (for a gas-filled lamp working at 22 lumens per watt). In practice an efficiency of about 14 per cent. is realised, but it is not clear whether this figure relates to the whole unit or to the transmission screen alone. This figure of course relates to the "blue sky" unit. For a sunlight effect the efficiency is greater, but must naturally fall considerably short of the ideal (33 per cent.) in an actual unit unless the accuracy of the correction is dispensed with. If an improvement in the quality is all that is desired naturally any sort of luminous efficiency can be claimed, but such units would totally distort the appearance of most of the sensitive colours, although producing an improvement in the value of blues and greens, etc.

Thus extreme care is needed in comparing more luminous efficiencies as such unless it is assured that the unit to be compared aim at the same type of correction. It has recently been cited as an objection to the Sheringham lamp that in efficiency it compared unfavourably with units developed in America possessing a 60 per cent. efficiency. We are told nothing of the type of correction of these units, but it is obvious that if they depend on transmission screens they cannot even approach a true sunlight quality, far less a blue sky, and therefore should hardly be compared with units that attempt to do so.

Furthermore, an unreserved discussion of luminous efficiency deliberately neglects to consider the important question of adaptation. When the excessive red and yellow intensity of an artificial illuminant is removed the eye adapts itself to the new conditions, and the light may appear to be relatively far brighter than the figures would suggest This applies more

especially to the shorter wave lengths which thus obtain a kind of subjective as well as an objective lift in value. It is no use to proceed on the assumption that the eye is a kind of photometer. The measure of the efficiency of an illuminant has to extend to many other considerations than apparent lumens per watt. If a draper loses an important order through not being able to guarantee the colour of a cloth, the efficiency of his lighting installation for the time being is something very near zero.

Other methods and units. Dufton and Gardner use an electric arc with a blue copper silicate transmission glass. The main objections to it will probably be those common to arc lamps. Dr. K. Mees has devised a screen for the correction of ordinary metal filament lamps, consisting of a special glass, together with a gelatine screen. Ives and Luckiesh have produced a similar screen.

In 1914, Ives and Brady produced a glass for accurate colour-matching with the Welsbach lamp. The "Moore" lamp (a carbon dioxide vacuum tube) is apparently the illuminant giving most general satisfaction, but it is said to be liable to get out of order and costly. Various "additive" methods have been suggested and employed in which electric lamps in plain and "signal green" glass are used together, but it will be understood that inasmuch as a relatively great amount of overcorrected light must be added to the light of a single uncorrected unit the advantage of the proceeding is not very manifest. Some of the difficulties in the use of transmission screens may be appreciated by studying the curves in Fig. 3 taken from a previous paper* for two "signal green" glasses.

Signal green is a most useful glass owing to its strong absorption of the longer wave-lengths. Cobalt blue† transmits the violet more satisfactorily, but also tends to transmit the longer red rays. A combination of the two with two layers of glass less strongly coloured, or the use of copper, cobalt, etc., together in the same glass leads to a possibility of varying the type of transmission. Beside the glass it is possible to add a gelatine screen in certain cases where the screen will not become hot. The gelatine screen coloured with a dye may be employed to reduce an excessive intensity in a portion of the spectrum where it may be required. Unfortunately the successive addition of components in this way may improve the relative energy distribution, but all tends to weaken the transmitted light. Furthermore, the proauction of glass having a *definite* absorp-

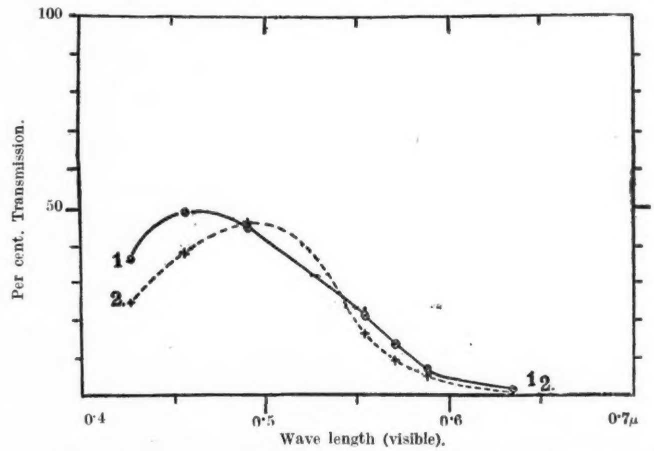


FIG. 3.—Spectral Distribution for two Signal Green Glasses (1) and (2).

* Light filters for eye protection. Trans. Opt. Soc., April, 1917.

† Not shown in the diagram.

tion is by no means easy as the exact result of a melting is not always certain, and correction with a dyed gelatine is apt to be dangerous owing to the fugitive nature of dyes under such conditions. The performance of the better transmission units, however, leaves little to be desired.

Sphere of artificial daylight units.—It seems at present to be generally agreed amongst dyers that for colour matching they need a lamp which will give exactly the same appearance to all materials as that ordinarily produced by light from a *blue* sky. This is naturally a fairly severe requirement. In the course of business they are required to match certain fabrics by dyeing others to appear the same in daylight. In the course of such processes the so-called sensitive colours often arise. Having made a daylight match the dyer (unless called upon to do so) apparently accepts no responsibility for the appearance of the products in artificial light or even in sunlight.

Of course, if a deep blue sky effect is required it must be provided, but it seems rather a risky type of proceeding especially in dyeing fabrics for summer use, when they may be worn in sunshine for the greater part of the time.

Where these sensitive colours are unlikely to be found and for most ordinary colour matching requirements, the main thing is to secure the best all-round colour values. Artists know that sunlight is not to be compared with north light for this purpose. The visibility curves for the various lights suggest this very strongly. Also the warm appearance of purple fabrics and objects is an argument against the sunlight type of illumination. I therefore suggest that the most desirable type of artificial daylight for general use will be found in a compromise between sunlight and blue sky light, in fact, a light something similar to that found on an ordinary dull day, which would be represented by a curve lying between those of sunlight and blue sky light.

For various particular industries it may possibly be found necessary to pay particular attention to certain parts of the energy curve if by any chance the transmission or reflection of a screen happen to be irregular in a certain part of the spectrum. This seems somewhat the case in some of the units I have tested. If it is so it will be appreciated that as the correct rendering of a colour may depend on the presence or absence of a small relative percentage of the spectral violet or the extreme red, the demands on an artificial daylight are likely to be, and actually are, very severe. Some of the transmission devices apparently have not given complete satisfaction to dyers requiring a blue sky effect, and in view of the difficulties of the problem this is not surprising. A good deal of the bother, however, may be due to the inevitable discrepancies of a changing day-light, and a more or less artificial source.

Diffusion.—The appearance and colour of fabrics depends greatly on the incidence of the light. The employment of a small source behind a transmission screen gives rise to harsh shadows and a different proportion between light entering the fabrics and light reflected from the surface. Some device for satisfactory broad diffusion is very necessary in an artificial daylight source.

Testing artificial daylight units.—The most severe tests seem to be actual visual tests with the so-called sensitive colours previously referred to. Where transmission screens are employed, the usual spectrophotometers may of course be employed to find the absorption of the filter. The success of the unit depends of course on the thermo-electric or photo-electric measurements of energy distribution on which from the most desirable type of absorption is deduced. It is very difficult, however, to forecast the effect of such variations from the ideal absorption as may be found at the ends of the spectrum, until actual tests are made.

Tests made by photographic methods are valuable, no doubt, but are liable to be extremely misleading unless made with the maximum of care and skill. Ordinary photographs of the spectra of north sky light and the light of a gas-filled lamp suggest little of their extremely great differences. Unless it is possible to make the exposure exactly of the sensitive length for the intensity in each successive part of the spectrum, the results are extremely insensitive. A modification of

the method employed in Messrs. Hilger's Sector Spectrophotometer might very possibly be useful for the photographic comparison of different types of daylight. A description of this is given in the paper to which reference was previously made. The necessity for such tests arises because some of the synthetic methods cannot be tested with a spectrophotometer, and tintometer tests prove nothing of the true nature of the light.

Several questions naturally arise as to the effect of variations in the lamp itself or the distribution of energy in the spectrum of the light which is to be corrected. It is well known for example that the efficiency of the gas-filled lamps tends to diminish considerably with a lower consumption of energy. I have not found any published data on relative spectrophotometric measurements between these types of lamps.* Apparently the initial difficulties of photometry with gas-filled lamps have not yet been thoroughly overcome.† Obviously the subject needs attention. Difficulties in correction will arise also on account of the voltage variations in ordinary electric supplies, for the quality of the light and distribution of energy in the spectrum are of course liable to change and it is not possible to provide any compensation for such a variable effect in an ordinary filter or reflector.

As far as my personal experience goes, however, effects of this kind (provided they remain small) produce no visually observable effect in the quality of the light unless perhaps some effects in ultra sensitive dye combinations are considered.

In any case while the variations of daylight are so exceedingly large it seems to be unnecessary to insist on a regularity so precise unless it is desired to produce a perfectly standardised unit for the dye industry. I do not consider either that the proportion of any particular condition of daylight can at present be fixed so nearly that an exact imitation can be expected from any artificial source.

* Slight differences are perceptible in " colour," between the larger and smaller lamps.

† Middlekauff and Skogland. Sc. Pub. Bureau of Standards, No. 264. (1916.)

PART II.—CORRECTION BY MEANS OF COLOURED REFLECTORS.

Mr. George Sheringham had for some time made use of a double-tinted reflector in conjunction with a metal filament lamp so constructed as to throw practically all its light on to the shade above it, and has been able to paint quite successfully at night by this means. This reflector was covered by washes of about equal areas, of green ink and blue pigment.

Eventually, in view of the importance of the subject in colour work, it was referred to the Technical Optics Department, Imperial College, for investigation.

On inquiry into previous efforts in this direction it was found that tinted reflectors have been used in America in Art Exhibitions, for *improving* the quality of artificial light, but that no attempt had apparently been made in any way accurately to re-produce daylight.

Accordingly it was judged expedient to examine carefully the spectral intensity value of the light reflected from a number of standardised pigments and dyes in order to estimate the possibility of correcting the light from some artificial source.

I am indebted to Sir William Abney for his kind permission to use the original " colour patch " apparatus for this work, and curves of the variation of percentage reflection with wave length for various pigments *as compared with the reflection of magnesium white* were carefully made. Major Klein, of the Camouflage School, Kensington Gardens, performed most of the experimental work on the absorption of the pigments, while both Mr. Sheringham and Major Klein have co-operated in making trial reflectors.

As this type of apparatus is not so well known as it deserves to be, it may be of service if a previous short description of it is quoted here. It makes use of an arrangement to form a pure spectrum in the plane of which a narrow slit is placed, thus emitting fairly monochromatic radiations. A " three pole " arc is used as a source. The further arrangement is shown in the diagram.

S is the slit moving in the spectrum, *L* the lens, which is so arranged as to throw the image of the first prism face in the spectrum apparatus on the screen *C*

half of which is made of the test colour, half of metal coated with zinc white. A glass plate or bundle of plates, M_1, reflects a part of the beam to the second mirror M_2, whence it comes back to the screen C. Sectors can be inserted in one or both of the beams. A rod R is placed so as to give two shadows, touching one another at C. We thus have one-half of the screen illuminated by one beam, and half by the other. The test specimen is placed in the main beam, and the brightness of the shadows again equalised by adjustment of the sectors. The rest of the room must be kept in absolute darkness. The measurement may be made for light of any spectral colour by moving the slide on which the slit is mounted. A scale giving wave-lengths is carried by the slide.

coated. The relative spectral intensity of the reflected light necessarily alters with the angles of incidence and of view, although the amount of alteration will not be very great except at oblique angles. It has not been judged expedient to take this effect into account at the present stage.

It is at once obvious that we cannot obtain a blue sky effect by a single extensive reflector, as we have to add to the direct light from the Tungsten gas-filled lamp a quantity of light from the reflector which for wave length $\cdot 45\mu$ must possess an intensity no less than about 12 times that of the direct light. This consideration then at once precludes the hope of any *general* satisfactory lighting by a single reflector alone, but it will be obvious that by the use of intensive

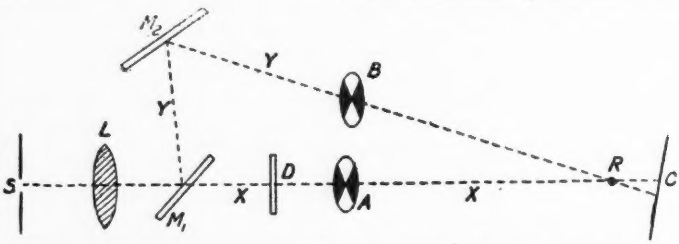


FIG. 4.—Showing arrangement of Abney's "Colour Patch" Apparatus.

Extremely good and consistent results can be obtained by the use of this apparatus, which is naturally more accurate than spectrophotometers of the Nicol Prism type, where the results depend on the squares of the tangents of angles.

The fact that the apparent luminosity of a screen, illuminated by light interrupted by a rotatory sector, is proportional to the angular aperture of the sector has been well established by experiment. Consequently it is only necessary to equalise the two shadows before putting the specimen in place and after, when the transmission follows simply from the ratios of the openings.

The source of light was the carbon arc, the incidence being normal: the reflected light was viewed at a constant angle of about 30°—40° with the normal (more especially in the case of certain pigments which give rather a "shiny" surface to the white paper on which they were

or semi-intensive reflectors concentrating a relatively great amount of reflected light we shall be able to produce a quality of light at certain points very much more nearly approximating to daylight quality than the bare light alone.

It is alternatively possible of course to reflect the *whole* of the light from a tinted surface, and, granted that pigments of correct properties are available, the excess of the longer wave lengths can be entirely absorbed and the entire illumination can be corrected.

The tables and curves corresponding to the performances of actually available pigments, coated on stout white cartridge paper, are now given. Reference may also be made to the results of Abney, who worked with opaque pigments coated with gelatine.

Assuming that zinc white reflects equally well throughout the spectrum, it will be seen that none of these pigments approach very nearly to the required

PERCENTAGE REFLECTIONS.*

Wave length.	Emerald Green.		Ultramarine.		Crystal Violet. 10B.	Methyl Blue.	Crystal Green.	Ver-milion.
	1	2	1	2				
·692 μ.	6·4	5·0	4·0	8·5	39·0	25·4	18·8	70
·665 μ.	..	..	..	..	12·7	..	..	..
·638 μ.	9·0	7·2	2·9	3·0	5·5	4·7	7·6	100
·589 μ.	18·9	18·2	2·7	2·1	4·4	5·2	8·8	80
·555 μ.	36·8	33·8	2·8	2·4	4·3	12·7	17·0	20
·510 μ.	..	..	5·1	..	8·3	..	..	..
·492 μ.	51·7	55·2	15·0	19·3	20·2	73·3	66·7	9
·465 μ.	34·7	..	35·5	..	41·2	..	..	..
·457 μ.	22·4	29·2	47·5	59·0	59·0	96·3	25·7	8
·427 μ.	8·5	10·0	43·5	56·0	75·0	..	16·0	7

* The reflection coefficient is given as relative to that of zinc white which itself possesses a total reflecting power of at least 80 per cent., and has a very regular reflection throughout the spectrum. Three fairly typical dyes are included (coated in a wash on white cartridge paper).

qualities, the general trouble being that the "absorption bands" are too narrow. Thus in the case of the "methyl" colours in which the reflection coefficient rises very nicely in the shorter wave lengths we are faced with trouble owing

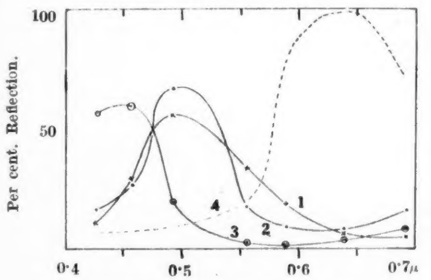


FIG. 5.—Percentage Energy Reflection Curves of Pigments.

(1) Emerald Green; (2) Crystal Green (dye); (3) Ultramarine; (4) Vermilion.

to a high reflection coefficient for the longer wave lengths in the red.

Emerald green is the only one amongst the pigments which disposes satisfactorily of the red, and there absorption gets very pronounced in the violet. Antwerp blue has been tested by Abney. The chief trouble with it is, however, that the relative absorption in the longer wave lengths is by no means sufficiently pronounced.

It is very possible that pigments may be developed by mixture or otherwise possessing more suitable reflection curves. The question of the permanence of a mixture is of course to be considered. For the first experiments it was considered desirable to combine the reflected lights additively rather than by the subtractive method.

This is done, of course, by coating the main reflector with pigments spread over certain definite proportions of area.

Having given the energy distribution in the spectrum of the lamp (quoted in Luckiesh's book on Colour), and the reflection coefficients of the pigments, the energy distribution in the reflected light follows very simply.

Adding the columns we may obtain a series of numbers representing the proportional distribution of energy in the light from a reflector tinted with equal areas of emerald green and ultramarine of the same saturation and brightness as the specimens on which the original determinations were made, as in fact the relative energy distribution from any proportions of the pigments.

Although the nature of the first curve is not perfectly satisfactory, it evidently represents a very considerable improvement on the ordinary; in fact the quality of the radiation will correspond very approximately to that of a "black" body raised to a temperature quite out of the range of practical temperatures on the earth.

The most unsatisfactory feature of the curve is its drop in the brightest part of the red. This is likely to influence

seriously the colour of the light, as the green component is unduly strong as compared with the red and violet; also it is desirable to get as regular a curve as possible.

Now vermilion has properties useful in this connection. Its reflection coefficients are approximately shown in the table.

General Discussion of the Results.

The combination given in the table show an increase in energy in the extreme red which is undesirable. Emerald green and ultramarine used alone in equal proportions produce a greenish hue in the reflected light which is due to the relatively great strength of the green component

RELATIVE DISTRIBUTION OF ENERGY IN REFLECTED LIGHT FROM "½-WATT" TYPE LAMPS.

	E merald Green.	Ultra-marine.	E.G. & U.M.
·692	9·5	5·97	15·47
·638	11·3	3·65	14·95
·589	18·7	2·67	21·37
·555	29·6	2·25	31·85
·490	25·0	7·3	32·3
·457	7·4	15·7	23·1
·427	1·9	9·8	11·7

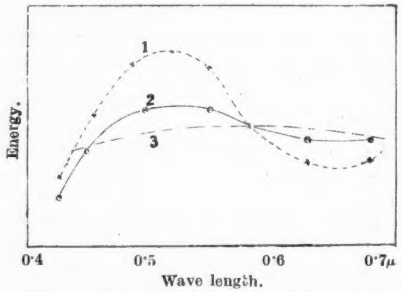


FIG. 6.—Relative Distribution of Energy with (1) Emerald Green and Ultramarine (1st correction); (2) Alteration with Vermilion; (3) Sunlight.

CORRECTION BY VERMILION.

Wave-length.	Vermilion Reflection Co-efficients.	Energy "V."	"V" / 10	E.G.+ U.M.+ V/10
·692	70	104	10·4	25·87
·638	100	125·5	12·6	27·55
·599	80	79·1	7·9	29·27
·555	20	16·1	1·6	33·45
·492	9	4·4	0·4	32·7
·457	8	2·6	0·3	23·4
·427	7	1·6	0·2	11·9

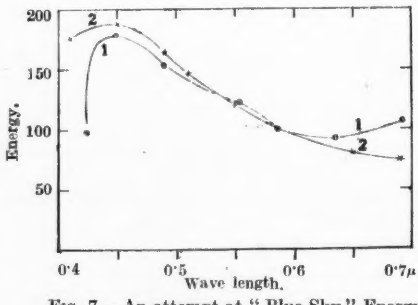


FIG. 7.—An attempt at "Blue Sky" Energy Distribution: (1) Connected Light; (2) Blue Sky (Ives).

It will be seen that by introducing a small relative area of vermilion into the reflector we shall improve the curve.

For plotting, the curves are reduced to equal ordinates with the comparison spectra at ·589μ.

as compared with the blue, but the effect is practically overcome when the proportion of ultramarine is doubled. In both cases, however, the energy in the orange-yellow part of the spectrum is a little low, and the result is very much improved

in the first case by the introduction of vermilion, which of course fills up the depression in the curve. The final effect is something very near sunlight, but it is possible to improve the light by slight variation in the proportions.

In a second case, in which the proportion of ultramarine has increased, the best blue sky effect, in which the proportion of blue light to red light is the greatest, is attained without any vermilion. The energy in the blue green is still a very little greater relatively to the blue and orange parts of the spectrum than is desirable. It may be corrected by a small amount of vermilion. A less amount probably produces the best all-round effect if the unit is to be used for sensitive tints of all kinds.

Photometric Measurements on an actual Reflector.

An approximate polar curve has been made for one of the early reflectors which was made up with emerald green and ultramarine with vermilion and aimed at a compromise between sunlight and blue sky. This confirms a result* announced in a previous number of the ILLUMINATING ENGINEER, that the distribution of intensity due to a concave matt reflector follows the cosine law.

The overall efficiency of the complete unit as computed from the measurements works out at 12 per cent. of that of the tungsten lamp itself, but no attempt had been made in any way to work with the most luminous pigments or to improve the condition greatly. It is only to be expected if care is taken to clear the best pigments, etc., that the efficiency may be raised by one or two per cent. at least. It must be remembered that this figure relates to the whole unit, and not to a lamp which must be used with diffuser and reflector. One or two points in the design of the reflectors should be noted as they have already been the subject of criticism. It must not be forgotten that the interior surface of the reflector is matt, and that consequently the *type* of light distribution under it is not altered greatly by altering its shape or angle. The polar curve remains very near a circle touching the centre of the aperture.

* Due to Halbersmatt.

D

Secondly, it is desirable that as much of the light as possible should be sent directly out of the unit without being reflected a second time. Therefore for the greatest efficiency the reflector must be as flat as possible. The necessity of limiting the size calls, however, for a concave form, and the glare from internal reflections in the lamp necessitates the provision of a narrow curtain preferably of light blue material, as a skirt round the bottom of the reflector. It may be a small point, but may it be suggested that manufacturers of gas-filled lamps should take more care to place the filament at the *centre* of the spherical bulb, in which case the image formed by reflection in the glass will be nearly at the same point and will no longer upset the action of carefully designed reflectors.

It should not be forgotten that the brilliancy of the image is about a tenth of that of the filament itself, a very considerable value. If the image is about an inch out of place some trouble is quite likely to result.

Efficiency of the Units. (Rough calculation for a New Formula.)

The mean percentage reflection of the various pigments at or near the "brightest light in the spectrum" will afford a very approximate indication of the probable efficiency of any particular combination.

Ultramarine reflects about 2·4 per cent. at $\cdot 55\mu$ (as compared with zinc white), emerald green 30 per cent. to 45 per cent. depending on the specimen and its manner of coating. At best then from emerald green (1) ultramarine (1) a reflection efficiency of about 23 as compared with zinc white is to be expected. The efficiency of zinc white is about 80 per cent., and if we consider the further losses we may have to take 80 per cent. of the value again, giving a final rough result of a total efficiency up to 15 per cent. for a lamp of this type.

For emerald green (1) and ultramarine (2) the efficiency of the light now giving a "blue" effect is indicated at about 10·5 per cent. A measurement on an actual blue sky reflection unit gave an efficiency of 9 per cent. Luckiesh's figures for actual transmission units aiming at the same effect show an efficiency

of 14 per cent., so that the relative discrepancy in efficiency is after all not so very great, and as was previously indicated it is not quite certain whether this relates to the overall efficiency of the unit or not.

General Remarks on the Method as Compared with Others.

The use of reflection for a correction is undoubtedly more difficult than the use of transmission, as we are faced with the fact that nearly all surfaces reflect at the surface anything up to five per cent. of light which never enters the colouring matter at all, and will therefore have a similar energy distribution to that of the incident light, if indeed it is not *adversely* affected. The cutting down of the extreme red then is rendered very difficult. The performance of the latest blue sky unit on the sensitive tints is, however, very satisfactory.

A word may be said as to the choice of pigments. Naturally the durability of these is a factor of the first importance, and we have been largely guided by the work of Abney* on the action of light on water colours. Emerald green, ultramarine and vermilion may probably be trusted under the conditions for the present purpose. Fortunately correction can be carried out very well by these alone, although the temptation to secure better though more transitory results by fugitive colours is naturally somewhat great. Specially chosen varieties of the pigments are necessary to produce the best results.

Dyes are very fugitive under such circumstances, and it is better to sacrifice a little accuracy than to make a very temporary correction.

The use of pigments offers too the possibility of making up definite standards of light. One can combine the effects of two or three standard pure pigments in this way, and be quite sure of the result which is to be obtained. I am not aware that glass of a definite type of absorption can be produced as easily. In fact, the reluctance of the glass-makers to undertake the manufacture of such glassware needs little comment. By the use of pigments, however, any type of energy distribution can be secured from giving effects from blue sky to sunlight in a perfectly definite manner.

The question of efficiency has already been discussed. I believe that from a good many points of view the satisfactory diffusion of the light is of great importance. This is accomplished automatically in the coloured reflector. As the surfaces are matt the diffusion is very perfect, and a "*natural*" appearance is given to fabrics.

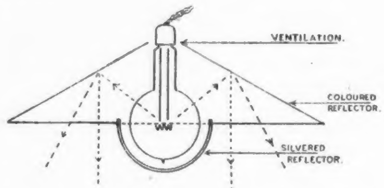


FIG. 8.—Diagram of Sheringham Daylight Lamp.

As far as cost is concerned such a coloured reflector can be made very much more cheaply than elaborate glass-ware, and, moreover, the indirect method of lighting offers greater freedom in the manner of using the system. For example, a whole ceiling could easily be coated with such an arrangement of colours if it were desired to light up very large spaces. Other possibilities suggest themselves for theatre and art gallery lighting.

Nothing has been said as to the correction of other sources of light, but the possibilities are being considered. Incandescent gas offers problems with the arrangement of ventilation, etc., for reasonable efficiency, but the correction need not be so drastic as the energy distribution is more favourable.

In conclusion, photographs of the spectra of north sky daylight and the Sheringham Lamp have been secured. These were taken on the same plate by a small reflecting grating spectrograph with a wire slit. The relative intensity of the Sheringham Lamp is shown to keep up well till the neighbourhood of 45μ is reached.

* Report to Science and Art Department, 1888.

DISCUSSION.

Following the reading of Mr. Martin's paper the Hon. Asst. Secretary (Mr. J. S. Dow), read in abstract communications received from Professor W. GARDNER and Mr. M. LUCKIESH, which, together with other written contributions by Mr. N. McBETH and others, will be found at the end of the remarks of speakers (pp. 48–58).

Mr. A. E. BAWTREE then described his colorimeter, which he stated was on the principle of the well-known Lumière autocrome plate, and involved the mixing of several colours in prescribed amounts, so that any hue could be accurately imitated or reproduced. The instrument consisted of two light-diffusing, systems which share equally the illumination from the source of light employed, preferably a metal filament lamp. The two areas are about 2 inches square and are placed in close juxtaposition—a condition essential to accurate matching of tints. On the one side is a plain white glass opening and a shutter worked by a micrometer screw divided into 100, the eye being able to read to half a division. The other side is illuminated by light passing through three adjustable shutters screened respectively by red, green and blue gelatines. When these three shutters are fully open a white light is obtained, but any variety of colour can be obtained by adjusting them in different proportions, which are registered on a scale. The intensity of the white light obtained by mixing the lights transmitted through the three colour shutters would naturally be less than that received in the white system, and accordingly a plate of opal glass is inserted in the latter, which served to bring the illumination into approximate equality.

In using the instrument a white surface is inserted in both systems, and the white light is adjusted until an equal illumination is obtained on both sides. The coloured surface to be matched is then substituted in the white-light system, and this is matched by adjusting the shutters controlling the amounts of red, green, and blue light.

The apparatus could be used with any form of approximately white artificial light. On the other hand, if it is desired to test any particular coloured fabric by daylight, in comparison with some artificial illuminant, the daylight could be admitted on one side and the other form of light on the other. It was a great advantage to be able to specify the nature of any colour by means of this instrument, and to dispatch the formula by post to any locality where it could be reproduced.

The PRESIDENT said that those who had followed the subject would be familiar with Mr. Lovibond's work with the Tintometer using a series of coloured glasses. Miss F. E. Baker, who was associated with the laboratory in which this apparatus was developed, had kindly consented to tell them something regarding new developments.

Miss F. E. BAKER exhibited a lamp intended for the purpose of providing a specific light for use with Lovibond's Tintometer. It was the outcome of many experiments by means of different lamps and screens to obtain a satisfactory laboratory light by which to make exact colour matches in the tintometer on dark days or by evening light to equal those matches made and recorded in normal north diffused daylight.

The illuminating surface was a standard white background screen or cupboard 3 ft. 9 in. high and 2 ft. 3 in. broad. No other light should be allowed to reach the object being tested than that of the lamp provided. The screens themselves were made up of specially graded blue-green glass of 1·5 tintometer units intensity mounted between two dispersers each of ·05 unit north light dispersive value. The lamp itself was of the $\frac{1}{2}$ watt 210 V 200 candlepower type. It was very important that the light reflected should always be at a constant intensity.

This, and a similar lamp, had been used for colour matching liquids and solids in the tintometer works with equal success: it was not yet satisfactory for all surfaces from which shades of colours are reflected, but samples were shown of colours of which the diffused

daylight and the artificial light measurements are the same and equal. There were, at present, three sets of screens provided for use with varying ranges of colour-depths. There had also been cases in which the measurements were not the same as those of daylight, but in these cases the artificial light curve had been established which, although slightly different from daylight, had been a constant curve and had therefore allowed of satisfactory comparisons being made with the daylight match previously obtained.

Mr. G. HERBERT exhibited the Benjamin Daylight unit, utilising a special transmission screen devised by Dr. Kenneth Mees, which was originally shown before the Society in 1912. Dr. Mees's screen was composed of two pieces of glass covered with or enclosing two sheets of gelatine coloured to the hues necessary to obtain a very close resemblance to daylight for the transmitted light. The screen used in the lamp now being exhibited was the identical one shown before the Society in 1912 and had been in use ever since. He mentioned this in order to confute the view that had been expressed that a screen of this nature would not be permanent. He understood that the standard of daylight adopted by Dr. Mees was a north light on a sunshiny day at noon, with surroundings (which had an appreciable influence on the colour of the light), consisting of green fields. Above the lamp, which was of the ordinary 100 c.p. tungsten type, was a white enamelled reflector which directed the light through the colour-screen.

Mr. A. S. JENNINGS, of the Paint and Varnish Society, expressed his interest in the paper from the standpoint of the decorator. In selecting colours for decorative purposes it was very desirable that the artist and decorator should be able to ensure that any particular colour of paint specified should be exactly the same as that used on former occasions. In the present circumstances this was extremely difficult, but no doubt the forms of artificial daylight described at the meeting would be serviceable in attaining this aim. A point of great consequence was the standardisation of the names of colours, as well as standardisation of the actual colours themselves. The first requisite was a standard of white light. The author had referred to sunlight, but what variety of sunlight did he select ? Would it be possible for this to be standardised, or would it be preferable to adopt as a standard some exactly reproduceable quality of artificial daylight ? This seemed to him the most hopeful solution of the problem.

Dr. J. F. CROWLEY said the subject was of great interest to the textile industry, where reliance on daylight often imposed limitations on output. For instance, in the technical colleges pattern weaving classes could not be conducted in the evening with any degree of satisfaction because of the absence of a suitable illuminant. That was naturally a drawback to many students who could only attend in the evenings. The same difficulty operated in factories.

He had recently seen, at the Imperial College of Science and Technology, Mr. Martin's demonstration of the Sheringham light, and the curves comparing the north skylight, diffused daylight, and light from a gas-filled electric lamp. He would very much like to see a similar comparison between the Sheringham light and the gas-filled lamp equipped with the coloured glass filter, as described in Mr. Luckiesh's contribution from the United States.

Another point on which he would like information was the influence on the colour of the light of variations in the voltage supplied to the lamp, which of course affected the temperature of incandescence of the filament, and hence the colour of the light it yielded. Possibly, for example, a 5 per cent. variation in voltage would have a material effect on the Sheringham light. A comparison of results obtainable with such units during the entire life of a gas-filled lamp would be of great interest, as it seemed possible that perceptible changes in the light given by the filament and in the nature of the selective action of the reflector might occur. This point seemed to deserve further investigation.

Mr. J. H. SUTCLIFFE (Army Spectacle Depôt) said he came across Dr. Martin some time ago when the latter was in the middle of his experiments at the Imperial College. When he (Mr. Sutcliffe) saw that light he came to the conclusion that it was built on the lines of the light he had been looking for a long time, as it covered a larger area of daylight than other daylight lamps he had tried. With this lamp it appeared that the larger the lamp was the better it was, whereas in other cases a relatively small area was illuminated. He was interested in the manufacture and matching of artificial glass eyes. In that work it was not only a flat-coloured surface like a print or coloured photo. that one had to look at, but superimposed layers of different coloured glasses and enamels, and one got different colours according to the angle at which they were looked at. It appeared to him that the variegated shade exhibited would very soon become dirty. Could Dr. Martin make his lamp a little more permanent when it entered the commercial stage—say a mosaic reflector, so that it would last a long time? Would it be practicable to reflect from some sort of permanent mosaic? Was there any difference between reflection from a dull and a polished surface?

Mr. WILLIAM WALLACE said that with regard to the remarks of the last speaker (Mr. Sutcliffe) he had been associated with him in connection with the Ophthalmic Centre attached to the Second London General Hospital, where there was an enormous traffic in artificial eyes. These could not be matched accurately, except in daylight—not after 3 p.m. in winter—owing to the difficulty of appreciating minute shades of colour in the enamels used for the iris, and a daylight lamp would have been of the greatest assistance.

Mr. Wallace said that he had been using the Corning daylight screen for about eighteen months in making water-colour drawings of the retina due to war injuries. Being fully occupied during the day, he had to do this at night. The Corning lamp was similar to one of the first of the American lamps shown on the screen that evening. The pattern used by the speaker consisted of an aluminium reflector painted white enamel inside. The larger aperture was closed by a Corning glass filter slightly bluish in tint. This illuminated an area about four feet in diameter. The illuminant was a 200 candlepower half-watt lamp. Placed between two tall windows with a north exposure, it blended with the daylight so that no difference was perceptible.

The Corning filter was the result of a series of experiments undertaken at the suggestion of Professor Gage of Cornell University, who wanted a constant light for bacteriological work, some of the delicate stains employed in his investigations being found to vary or become invisible in certain lights. Before the glass for the filter was passed, each pot was tested so as to obtain accuracy. The distribution of energy in the spectrum of the glass approximated that of sunlight, particularly in the region of the visible spectrum giving the greatest amount of useful light. The filter has been fully described in American scientific journals. The advantage of the filter lay in the ease of its application, and the elimination of all empirical devices. Harrod's has now a consignment of Corning glass for cooking purposes, and doubtless would be able to procure filters. The Sheringham light seemed much more blue than the Corning filter. The speaker mentioned that he had seen in the showrooms of the Mazda Company a lamp designed for artists, in which the light was not unlike that obtained by the Corning filter, and the Kodak Company also had a lamp with a gelatine filter for comparison of coloured fabrics.

(After the discussion, Mr. Wallace, specially interested in the analysis of colour from the point of view of the artist, tested the three lamps shown with Winsor and Newton's Handbook No. 43, "Washes of Modern Water Colours." He found that the series of yellows, some of which were invisible under ordinary electric light, were perfectly defined under the 500 candlepower tungsten lamp, and the same under the Sheringham device, with this qualification that a faint greenish tinge was appreciable under the latter).

The PRESIDENT remarked that English lamp makers had made some blue glass lamps, and it was to be hoped that they would follow the American practice of developing such glass in this country.

Mr. F. E. LAMPLOUGH (Messrs. Chance Bros.) said that as scientific glass manufacturers they had not had much opportunity during the last few years of dealing with anything outside optical glass requiring scientific experiment. In the course of work on neutral glass they had made many measurements on the colouring powers of various oxides, so that a large amount of preliminary scientific work had been carried out, and they were now engaged in completing that work and hoped if no unforeseen difficulties arose to put on the market a glass to give the daylight effect somewhat on the lines described that evening. Glass melting, with proper care and scientific control, could be made very constant. He was not surprised that the lecturer had found two samples of signal green which differed considerably. Different railway companies insisted on different standards of green for their lamps. With proper control, there should be no insuperable difficulty in producing standard results, but seeing that daylight was not constant and lamps were not run at constant voltages and curtains and walls, etc., modified the effects produced he did not know that absolute constancy was really essential, and perhaps too much had been made of the difference between the north light and sunlight. There was an alternative to the three-colour method for assessing colours—in terms of white light, plus or minus a certain amount of a pure spectrum colour.

The PRESIDENT said that this was the third occasion on which the subject of colour-matching by artificial light had been discussed by their Society. At one of the former meetings* he had referred to some suggestions which he had made some 28 years ago† on artificial daylight. The time had now arrived when this had become practicable, and before considering the best method or methods for producing artificial daylight it was desirable to examine the kind of light required. It would be found that distinctly different qualities of daylight were applicable for different purposes, for example, artists' studios, picture galleries, drapers and dyers, industries such as milling where the grading of flour had to be examined, and other purposes. They had heard about "north light," "blue skylight," summer sunlight, and so on, they had been shown energy curves, visual intensity curves and other methods of describing the kind of light to be produced and the degrees of success in producing it.

Artists always preferred a north light, and dyers state that such a light is essential for the matching of certain dyes. He believed that the chief reason for a north light for an artist's studios was that such a light was more constant than any other and that for this purpose, constancy was of more importance than quality. An artist wished to be able to work for several consecutive hours without being bothered by wandering beams of sunshine which would necessitate the use of blinds and curtains. It is true that even with a north light the colour of daylight varies very considerably when bright sun-lit clouds pass across a blue sky. That cannot be avoided, but it is better than changing beams of sunlight. Even if a landscape is painted out of doors and represents full sunlight the picture will be seen when it is finished in diffused light, and it is generally completed in a studio. He believed that most artists would be content with a light of the colour of subdued summer sunlight, and it would be more easy and less expensive to produce such a light artificially than a "north light" or a "blue skylight." Mr. Kenneth Mees had gone further and had produced a photographically correct white light. He could not help thinking that Mr. Sheringham had been trying for too white a light.

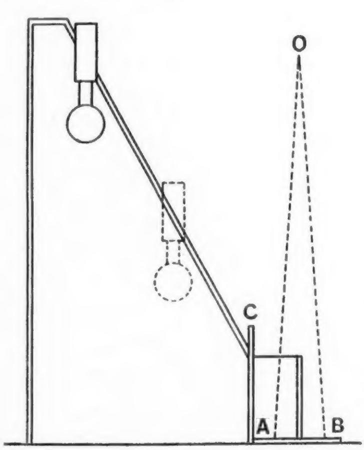
But Dr. Martin had showed them specimens of dyed materials which behaved in a strange manner and the question arose whether the pigments used by artists acted in the same way.

* ILLUM. ENG., Vol. V., p. 76, 1912.

† *Journ. Inst. Electrical Engineers*, Vol. XXI., p. 360, 1892.

He had found no evidence to show that this was the case. These freak dyes were so uncommon that among his lady friends we had found none who had noticed differences in matching of dress materials in sunshine and in shade, but it was quite evident that dyes are now being used which give very different colours under such conditions. It is true that a dye which yields a colour matching a given colour either in sunshine or in the shade is a better one than a dye which gives different colours; but the erratic dyes must be dealt with, and their appearance under a diffused north light must be examined.

The curves of energy in the visible spectrum could only be obtained by the skilful use of rather elaborate apparatus, and when they had been obtained they could only act as a guide to the desired result. It was difficult to predict the visual result due to a variation of such a curve. After using a spectrophotometer he had found it necessary to make direct comparisons between the appearance of any given pigment under artificial light and under daylight. He had shown at a former meeting of the Society an apparatus which he had made for this purpose and he would describe a modification of this which he thought would be useful.



A specimen of painted or dyed material A B is half covered by a box containing a lamp and open at the bottom. The material is observed from the direction O, half of it being illuminated by daylight and half by artificial light. The position of the lamp can be altered to control the brightness of the illumination, and the interior of the box may be coloured, as in Mr. Sheringham's method, or a glass screen C of the requisite blue-green colour may be used.

Mr. G. Sheringham said he agreed with the President that there would be probably a more general use for the artificial light that aimed at a *Sunlight* effect than for the *North-sky Light* one, because it could be achieved with less loss of luminosity. He had therefore already applied his invention in three different formulas—" North-sky Light," " Diffused Sunlight," and " Sunlight "—and it was possible to have his reflectors so designed as to suit almost any particular purpose for which special lighting was required. For instance, each department of a shop should be specially lighted—either with a view to (1) most accurate colour-matching, or (2) to really good colour effect (but where absolute accuracy in colour-matching is not essential), or (3) the effect of a general cheery glow. At present, instead of aiming at this last (in their tea-rooms, staircases, etc.), as the most attractive light, most of the big stores (ignoring that this can be achieved by employing certain colours on a reflector) frequently employed an almost blinding brilliance. This, by over illumination, defeated their own object, because it destroyed the richness in the colouring of their goods. Similarly the present fashion of using highly coloured silk lampshades—while recognising the principle of utilising a cheerful colour, such as rose or orange—defeated the art and trouble that the owner of the room has expended on carefully selecting the various contrasting colours of the curtains, carpets, cushions, etc., into an harmonious whole—by rendering them as merely varying shades of a monochrome.

He thanked both the President and the Society for the honour they had done him by allowing him to show his invention at the meeting, and to take part in what had proved a most interesting discussion.

Mr. L. Gaster said that the discussion aptly illustrated the value of the impartial platform provided by the Society for the discussion of novelties of interest to many different expects. The subject was a complex one, and the discussion had been useful in assembling much scattered information. He would like to mention that an excellent summary of work done on "artificial daylight" had recently been contributed by the President (Mr. A. P. Trotter) to the *Times* Engineering Supplement. He hoped that any gentlemen unable to join in the discussion at the meeting would send in contributions in writing.

Several speakers had referred to the need for a standard series of colours, with specified names for each. A particularly comprehensive series, occupying several hundred pages, was that prepared by the Société Française des Chrysanthémistes, in two volumes, wherein not only a very great selection of tints, but the suggested names for them were presented in four languages. Naturally this series of coloured plates did not obviate the difficulties arising from the nature of the light by which the colours were illuminated, but it at least provided a complete set of identified hues with which to experiment. By reference to a specific illustration on a certain page one could telegraph particulars of any desired colour, by the aid of this publication. The Society would be glad, if desired, to form a joint committee with other bodies interested to consider in detail the various points arising from the discussion. He wished to express to Dr. Martin and other speakers his personal appreciation of their useful contributions on this important subject and of the demonstrations which they had prepared at somewhat short notice.

Dr. R. Lessing (*communicated*): I am sorry that I was unable to remain for the discussion of Mr. Martin's interesting paper, and there are one or two points I would like to bring before his notice. I observe that Mr. Martin has emphasised the difficulty of matching delicate shades of colour by artificial light. It might possibly be inferred that the appearance of so-called "white" colours was of less moment. As a matter of fact the matching of these whites is quite as difficult as matching the more complex colours. The problem arises very frequently in the comparison of white pigments and other chemical products, where one has to distinguish between various shades of white, and again in the sugar, starch and flour industries, where samples are graded by colour. As a preliminary to a recognised scale of colours agreement upon a standard white would be extremely helpful. Such a standard should be reproduceable and permanent. I notice that Mr. Martin refers to the use of zinc white, but it is well known that this material, in common with many other white substances, varies very considerably in colour according to the method of preparation.

Mr. E. R. Grills (*communicated*): It would seem that any attempt to define daylight exactly, for the purpose of setting a standard for the so-called artificial daylight, is almost impossible; or at any rate severely limited. Not only is the light emitted by the sun of a very complex nature, by reason of the great number of substances burning therein and manifested by the large number of absorption lines shown in the solar spectrum, but also on account of other varying and qualifying causes such as the changing atmosphere—thickness of layer, the presence of varying amounts of water vapour (which last shows prominently as absorption bands round about 6,000 a.u.). Even if these difficulties could be overcome there would remain the fact that the sense of colour is physiological and varies not only between people, but in any one person in different circumstances. A point which does not seem to have been mentioned in the paper is the fact that the intensity of the artificial daylight illuminant governs to a great extent the type of colour and the range of colour which it is possible for one to conceive and to be enabled to match or attempt to match.

I refer to the Purkinje Phenomenon.

Purkinje showed that the range of colour perception in a given strength of bright daylight (wherein all the yellows, reds and yellow greens were virtually the brightest, as compared with the blues and blue-violets), did not obtain when the light had diminished, during the twilight.

To prove this fact it is only necessary for one to go into a flower garden by bright noon-day and again in the twilight and to observe the relative brightness or intensity of colour of the flowers. It will be seen that the dark blue and blue-violet flowers during the twilight are visible long after the orange, red and yellow ones have disappeared and seem apparently black.

It cannot be explained away that the great thickness of atmosphere is responsible for this phenomenon because such a condition tends to absorb the blue waves first. Therefore, it would seem to be a physiological effect, which has been ascribed to the fact that we have in our eyes a varying number of Rods (which are sensitive to blue) and a fewer number of Cones (which are more sensitive to green, yellow, orange and red). These Rods and Cones are not evenly distributed. The percentage of the Cones is much greater towards the centre of the sensitive region, but diminish rapidly in ratio towards the outer edge of the sensitive region where the blue sensitive rods greatly predominate. Therefore, there are more Cones presented for stimulation by bright noon-day at which time the iris of the eye is comparatively closed; and at eventide when the intensity of the light is less the iris of the eye is open much wider; thus permitting the stimulation of a proportionately larger number of blue sensitive Rods. This possibly explains why a night sky appears of a bluish colour.

The importance of the intensity of any light (whether it be daylight or light from an artificial daylight unit to be used for colour matching or colour effect observations) cannot, it would seem, be overstated; and it would appear desirable to standardise the light intensity of any artificial daylight unit against daylight which should be dimmed down by means of a neutral carbon graded filter.

Prof. W. M. GARDNER, Bradford Technical College (*communicated*):—My interest in the subject of colour matching dates from 1895 when I took over the charge of the Chemistry and Dyeing Department of Bradford Technical College from Mr. Arthur Dufton, M.A., on his appointment as Inspector under the Board of Education. Having a family connection with the dyeing industry, Mr. Dufton was well acquainted with the insuperable difficulties under which dyers were placed in dull and foggy weather which were so serious that the final matching-off of dyeings was often quite impossible in winter for days together; this resulting in great delay and much extra expense.

For the accurate matching of colours, dyers always preferred the direct light from a north sky, but even this, apart from its variability from hour to hour, is apt to be appreciably changed by such adventitious influences as the passage across the sky of a sun-illumined cloud, or the reflection of red-tinted light from a brick building. It was evident therefore that the introduction of a reliable artificial illuminant giving light of the same quality as that from a northern sky would be an immense boon, not only to the dyeing industry, but in all trades where the accurate evaluation and comparison of colours was important.

Theoretically, the problem was comparatively simple, consisting as it did of the selection of a reliable radiant, containing rays from the whole of the visible spectrum, and the absorption, by suitable means, of the excess rays from those portions of the spectrum of the light which caused the radiant to differ from standard daylight.

Mr. Dufton and I joined forces in the investigation, and we first examined all the possible illuminants, including coal gas, paraffin oil gas, and acetylene gas, burnt under mantles of varying types, and many varieties of incandescent and arc electric lamps. Practically all the illuminants, even those which appear to give a green light, contain an excess of red rays, and eventually we fixed upon an arc lamp of the enclosed type as being the most suitable source. In such a lamp, which burns with a long arc of $\frac{3}{4}$ in. to 1 in., the light emanates from two sources, the

arc itself (which contains much violet and ultra-violet) and the glowing carbons (which give a considerable excess of red rays). The light from these two sources, when thoroughly mixed by diffusion, gives a steady source requiring the least possible correction. The light from all types of evacuated or gas-filled bulbs has the common defect of changing in character with the age of the lamp.

Having settled upon the illuminant, we proceeded to investigate the best correcting medium. Transmission through stained gelatine films, commercial coloured glasses, and all possible types of solution was tried as well as reflection from coloured surfaces. Incidentally it was noticed that all artificial dyes, even the brightest greens, transmitted a band of red light, and the best results were obtained by transmission through a solution of a cupric salt of suitable concentration with the addition of a small amount of a yellow dye to cut off the excess of violet which the light contains.

After great tribulation a glass suitably tinted with a cupric salt and a trace of uranium was commercially produced and the "Dalite" lamp was patented and put on the market in 1899. The lamp contains three essential features—a long arc as radiant, the distributing screen, and the correcting screen. It has proved very useful, and is in use in most large dyehouses in this country and abroad. The patent specification (No. 23476/1899) claims: "The use in conjunction with electric lamps or other sources of artificial light, of coloured screens or reflectors, so selected as to intercept or absorb such coloured rays as are found to be in excess of normal daylight, for the purpose of rendering the light of the same quality as daylight and suitable for matching or viewing colours." For the purpose of quickly testing the accuracy of lights a series of patterns, very sensitive to colour changes, was produced, and these proved to be the most sensitive indicators available.

Of course a discussion of the subject of colour matching involves chiefly the question of the optical properties of the coloured objects concerned, be they dyes or pigments, and in this connection it may be of interest to describe the method I have adopted for class purposes. A dyed gelatine film mounted on glass is placed in the slide carrier of a lantern along with a cover glass completely masked save for a clear slit about 1 cm. long by 1 mm. wide. In this way a coloured strip is projected on to a white paper screen placed five or six feet away and by holding a defraction grating in front of the objective the absorption of the colour may be examined. By scraping away a portion of the dyed film and mounting up with a mask containing a slit 2 cm. long showing half dyed film and half clear glass, a complete spectrum is produced on the screen alongside the absorption spectrum; and by using slits 3 cm. long showing two-thirds white and one-third colour, and placing two such slides in the carrier, arranged head and tail, the absorption of any two dyes may be compared, along with that of white light for reference. By this means the reason for normal and abnormal colour-mixture effects may be clearly demonstrated collectively to a group of students.

Mr. David Paterson (*communicated*): I have read with great interest and appreciation Mr. Martin's excellent paper, and congratulate him on his treatment of a difficult and complex problem with all workers in colour, and more especially with dyers and textile colour matchers. Many colour experts have no doubt been disappointed with the results of several so-called "daylight substitutes" put upon the market. They claim to give the true colour effects of daylight, and to establish their claims exhibit paintings, cases of butterflies and moths, and other natural history specimens, and dyed samples of silk, etc., etc., to show that all these coloured objects appear quite natural and "daylight" in appearance under their advertised illuminants.

But to the textile colourist this is no criterion at all, and the author does well to draw particular attention to these super-sensitive dyed shades which change very much under an artificial light. Indeed, I have seen in several of these abnormal shades changes of hue taking place two or three times in the course of one day, owing to the varying qualities of the ordinary daylight. Some of these reputed substitutes for daylight prove

quite useless for the careful matching of dyed textile. I have as yet no personal experience with the new "Sheringham lamp," but I wish to point out that it is quite possible to paint pictures correct as to tone and hue under a good incandescent gas light, which would yet be of little service to the colour matcher of these super-sensitive dyed shades.

The different optical structures between paints or pigments and *dyed* materials is a very important point which colourists are apt to overlook or not be fully aware of. I have shown to artists, using paints all their lives, colour changes under gas light which simply amazed them. It is therefore well to remember that pigments show but little change in a good incandescent light compared with the changes shown by dyed textiles.

I don't agree altogether with the statement that the generally accepted light for dyers and colour matchers is the light from a *blue* sky. The generally accepted standard among textile colourists is a well diffused white north light, or from a grey sky, or a bank of white cloud. The standard light is obtained on a day when the sky is uniformly covered with light grey clouds, or where there is a certain quality of white mist, *not fog*, but mist. Such conditions give the truest and most diffused light for colour matching purposes. The author is therefore quite right in suggesting that the most desirable type of light is the "compromise between sunlight and blue skylight." This you will generally get from a north light.. It is the best diffused.

It might be mentioned that though these abnormally sensitive dyed shades as described are theoretically of great interest, the skilled dyer tries to avoid them as much as possible in general practice. If he finds his dye combinations create this unstable optical quality, he is wise to use a different mixture so as to produce an optically more stable shade. A piece of cloth dyed with a shade showing such abnormally sensitive qualities that the peculiar "macula lutea" spot was seen wherever it was looked at, would undoubtedly be considered "faulty" in ordinary every-day practice. This could only be avoided by the dyer changing his combination of dyestuffs. Owing to the unstable quality of daylight and the long winter months, when the light is both short and poor, especially in large towns, it is very essential that a good standard daylight lamp be devised. A few are wonderfully good—the "Dufton-Gardner," for example—and the satisfactory solution of the problem certainly lies along the lines laid down by Mr. Martin in this interesting paper.

Mr. M. LUCKIESH (*communicated*): In response to the invitation extended to me to contribute something to the discussion, I will dwell briefly on the realisation of artificial daylight practical in the United States. We passed through the stage of development some years ago and are now able to discuss the subject as a result of practical experience.

There is a need for standarising daylight—perhaps north skylight and noon sunlight—for purely scientific reasons. The practical need of such standardisation does not appear to be as urgent at present as it appeared to be a few years ago.

We began the development of artificial-daylight units by means of spectrophotometric analyses of daylight and reproducing what we considered to be average values. Experience gained in practice has also led to minor modifications of the glass filters. After all, it is only theoretically possible to match a given quality of daylight and the best quality of daylight must be determined from spectrophotometric data and a large experience factor. Our judgment is now reinforced by the judgments of many expert colorists and the various types of units which we now have developed have apparently definite fields for use. Naturally a number of units have appeared on the market, some of which have been unsatisfactory, but the latter soon disappear because they have not been based upon spectrophotometric data.

Generally the artificial-daylight units in this country are tungsten (Mazda C) lamps equipped with coloured glass filters. We have developed three general types of artificial-daylight units and these are designated as north-skylight colour-matching units, noon-sunlight units, and Mazda C-2 lamps.

There are about 15,000 north-skylight

units in operation at the present time, and the demand is rapidly growing. These units vary in design from cheap industrial fixtures to elaborate store-fixtures and the sizes of the lamps vary from 100-watt to several 500-watt lamps per unit.

Fig. 1 illustrates a small north-skylight unit with the glass filter in the aperture of the reflector. This may be attached to an ordinary lamp-socket. Fig. 2 illustrates the use of a small counter-unit in stores. Besides these the stores use the larger units in their triplicate-mirror booths. Typical installations of the artificial north-skylight units are shown in Figs. 3 and 4.

Experience has shown that the average eyes are not sufficiently trained and that many needs are insufficiently exacting to demand a highly accurate artificial daylight. Furthermore, a large demand developed for fairly efficient units for general lighting purposes; accordingly a compromise between luminous efficiency and quality of light was made in the noon-sunlight units and in the Mazda C-2 (daylight) lamp. A coloured glass is made in the shape of globes and acorns for use with the clear-bulb Mazda C lamp. These are largely used in industrial establishments in connection with

FIG. 1.—A small Colour-matching Lamp Unit which may be attached to a socket.

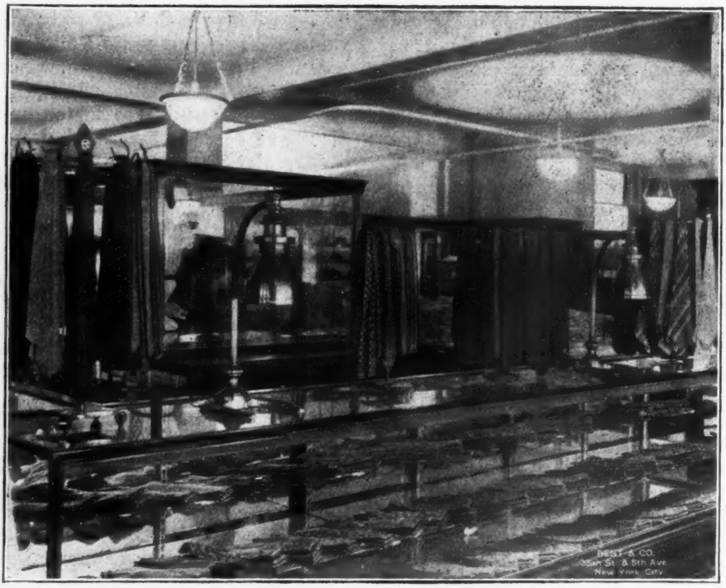


FIG. 2.—Showing Counter Colour-matching Units as used in a Clothing Store.

FIG. 3.—Large Industrial Colour-matching Units used in a Silk Store.

FIG. 4.—A large portable Colour-matching Unit as used in Purchasing Goods.

standard reflectors, but are also used in groups in a very artistic manner for general lighting in stores. The noon-sunlight units provide a quality of light approximating to noon-sunlight. Another glass was developed for the bulb of a gas-filled lamp and by sacrificing one-third of the light emitted by the filament, a great advance toward noon-sunlight has been made. The result is similar to actually raising the temperature of the filament very considerably. Several million of these lamps have been installed, and that there are at least a million sockets at the present time containing these lamps.

These artificial-daylight units are based upon the subtraction of excess rays in correct proportions which means a loss in luminous efficiency. In fact, the luminous output of the north-skylight units is reduced to about one-fifth that of the light-source; of the noon-sunlight units to about one-half; and of the Mazda C-2 (daylight) lamp to about two-thirds of the output of the filament. However, it is interesting to note that little objection is met on the score of decreased efficiency. By subtracting some light an unsatisfactory illuminant is made satisfactory, hence the efficiency in a broad sense has been *increased*.

There are now few stores and industries in which a need for such illuminants cannot be found, and art museums are awakening to the possibilities of modern lighting. Furthermore, many are testifying as to the superior quality of artificial-daylight compared with ordinary artificial light from the standpoint of comfortable vision. There is reason to believe that sensitive eyes which are irritated by artificial light, but not by natural light are comfortable under artificial daylight even when all conditions excepting quality are constant.

I trust this aspect of the subject will be of interest to your Society, for whose prosperity I wish to convey sincere good wishes.

Mr. J. S. Dow (*communicated*) :—
Little reference has been made in this discussion to the Moore CO_2 tube which is said to have excellent qualities for matching colours. It is of scientific interest to inquire under what conditions luminescence from a rarified gas, which presumably gives a line spectrum, can reveal colour correctly. Apparently if the lines are sufficiently numerous and evenly distributed small gaps in the spectrum are not of great importance.

Mr. Norman Macbeth (*communicated*) : In the development and manufacture of lighting apparatus or fittings for use in the observation of colours, we have had to do considerable pioneer work. For the proper and easy observation of objects or materials from the standpoint of colour, especially where the colours or shades are dark, with a correspondingly low reflection factor, a high initial illumination is essential. Our experience has shown that 5 to 10 foot-candles is of little use, that less than 50 foot-candles (50 lumens per square foot) is not as satisfactory as intensities from 50 to 100 lumens per square foot. That observation is usually confined to a comparatively small area, and hence these high intensities can be furnished at a reasonable cost.

The need for this high illumination arises partly from the possibility of dark colours, but also from habit, as natural daylight intensities run up to thousands of lumens per square foot, and the observer of colour demands not only colour purity of light, but also the brightness equivalent of natural daylight. The usual first demand of the prospective customer is for a scheme of general illumination. This we consider unnecessary, extravagant, and quite beyond any possible justification with the intensities that are demanded for clear vision.

These intensities without any colour correction, that is, in "raw" artificial light, require a wattage approximately ten times that in general use, even in our most brilliantly lighted stores. This is with the ordinary gas-filled tungsten filament lamp. If, however, a correspondingly high intensity was desired over a large area with a light even approximating daylight in colour—even late afternoon daylight with its comparative excess of red from the setting sun—the absorption of the light generated by the "half-watt" lamp would not be less

than 60 per cent., so that the wattage input for a drygoods or department store area, per store bay of 20 feet, 400 square feet, would be increased from 1 watt per square foot to 25 watts per square foot, an increase from 400 watts per bay to 10,000 watts per bay, with a corresponding cost of 2,500 units for each present 100 units of cost.

Aside from a limited demand for reproduced daylight for use in observing certain chemical reactions and for the appraisal of diamonds, of raw silk, cotton, coffee, and similar observations, we have found the equipment furnishing an ordinary artificial light or " evening light," as it is generally called, is quite as practical and useful as that supplying the daylight equivalent. So much of our activities are under evening light, that noting the appearance of objects under this light is essential to the user's satisfaction, particularly in wearing apparel and textile materials, draperies, wall and floor coverings, and dyed stuffs generally.

The same dye will result in different colours in different fabrics—silk, cotton, wool, and various mixtures. Different dyes may be used in different materials, with the result that colours will match or be in harmony, or combine in a pleasing contrast as may be desired under daylight—or under evening light—depending upon the point of view in their selection. Rarely do we get similar colour sensations with the same fabric when observed under daylight and under evening light, and frequently an harmonious combination under daylight will be in violent contrast under artificial light, and the same is true of selections made under artificial light when viewed in daylight.

This condition is responsible every year for tens of thousands of pounds loss in goods returned, later to be sold at a reduction on the remnant counter, and for other thousands of pounds in value not received because the wearer " didn't like it." For example, the dignified gentleman with his modest navy blue serge does not maintain his dignity with the " sport " purple appearance of the same suit at luncheon, afternoon tea or elsewhere under artificial light in the day time.

We have exclusive evening wear, but no exclusive daylight costumes. While evening colours may be selected under artificial light only, all day wear fabrics must be selected with the point of view of being seen in both daylight and evening light.

FIG. 1.—Portable Colour-matching Unit with cover attached.

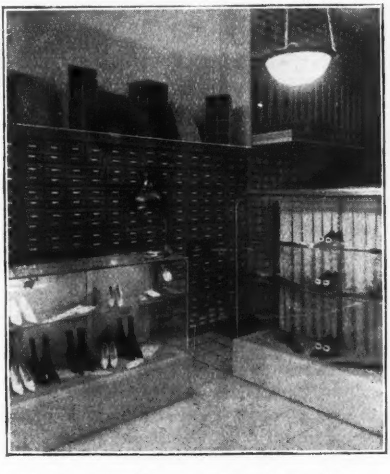


FIG. 2.—Showing use of portable Colour-matching Unit in a Boot Store.

Furthermore, few individuals, if any, have a sufficiently developed colour-

memory to enable them to properly observe and classify daylight colours at the door or at a convenient window, and the evening colours of the same materials a minute later in a so-called "evening-room"—with which many of our stores were formerly equipped. Our observations on this point tend to the conclusion that the average individual's colour-memory is of little longer duration than one-tenth of a second. At any rate, much more satisfactory conclusions can be reached as to colour sensations when the object or material is observed first under daylight and then under evening light, when neither the object nor the observer is moved, when the light is alternated instantly from the reproduced daylight to the evening light without any observable period of darkness or of mixed light coming between these two widely different colour effects.

We have a system of sound notation in our music note characters, and any harmony or discord can be reproduced on a similar musical instrument from a written notation. So far as I am aware, we have no similar system referring to colour, none at any rate that has received general recognition.

A large proportion of our people can read and interpret music on a variety of instruments. We also have many individuals who are admittedly not musical, who are not musically educated, who also have no colour education but who are not aware of their colour ignorance. How is a man, therefore, who knows a thousand colours, shades and tints, to describe any colour intelligently to another whose knowledge may extend to the primaries or at best to ten colour names, and how can the latter describe a colour to the colour educated man? There is also the partially colour blind to contend with, those who are slightly colour blind in blue, green or red.

It would seem that we have an infinitely greater number of individuals possessing normal hearing organs, than we have those with normal visual organs. The conclusion is, therefore, that we can be sure a colour is pleasing, is harmonious, or is in contrast, as may be desired, only when it is seen by the individual who is interested in its use for its purpose.

Our organisation has paraphrased the service of our equipment in the statement that "This is the device that answers truthfully with the observer's own eyes every question as to colour, pattern or fabric, both in day and evening effects." All our fittings have consequently been arranged to give both a reproduced daylight and ordinary evening light effect controlled by switches so that the circuit may be alternated from one to the other, but the two lights cannot be mixed.

Ordinary incandescent lamps are used, the vacuum tungsten for the evening light, and the gas-filled or "half watt" tungsten lamps for the daylight. The latter is corrected as to colour by transmission through a pot glass disc or filter. This filter appears as a rather dense blue by daylight, but when you look through it into the interior of the lighted fitting, it is not difficult to believe that the surface of the reflector and the incandescent lamp seen within are enclosed with a disc of clear colourless glass.

In the beginning of our commercial work, five years ago, we adopted a standard of colour equivalent to the direct light from the sun at noon. This resulted in a higher percentage transmission of light than with a north skylight equivalent, and was in this particular a leaning towards the engineering point of view of a higher efficiency. Later we decided that a real high efficiency would be secured if we gave our customers that colour of light to which they were accustomed in natural daylight. This ranges from a sunlight equivalent on the red extreme to that of a clear blue sky, or, as it is generally called, north skylight.

Our most exacting demand comes from the silk dyers and the silk converters' examiners, the bleachers, and the diamond experts. The least exacting are the stores and the colour printers and lithographers. The latter seem to be satisfied if they can distinguish a yellow ink impression on a white or cream paper or blue over black.

To have a means of reproducing daylight has in our experience been about as valuable to the average possible user as would be the possession, by the average layman, of a case of incandescent bulbs without the necessary fittings, reflectors, and knowledge of how to use same to advantage deemed as necessary to-day.

We have found the development of fittings, their ventilation and artistic completeness, their fitness to the location and the purpose for which they are desired, was an infinitely greater, more diversified, and certainly more expensive development than was the wonderful scientific achievement—the development of the filters for the reproduction of daylight from electric and gas incandescent lamps that made our later work possible.

We are now using practically all sizes of gas-filled lamps, from the low voltage 25 watt lamp to the 250 volt 500 watt lamp, and have standardised the colour of the light from these lamps with the various necessary corresponding filter concentrations into a range of daylight equivalents from sunlight to north skylight, divided arbitrarily into over one hundred intervals representing the extremes at each end, and various mixtures of each in the wide range lying in between.

The fittings are all of the direct localised lighting type.

The glass filters we use are broadly of two kinds, due respectively to the independent research and development work of Drs. Herbert E. Ives and Henry Phelps Gage.

The glasses are of a lead potash base with various proportions of cobalt, manganese, nickel and copper, and are pot glasses, that is, the mixtures are effected in the molten mass from which the glass is then blown or pressed, as may be required. The blown glass goes through the usual process as in the making of window glass, that is, cylinders are blown which are later split and flattened into sheets. The blown glass has been used in thicknesses of approximately 4 mm. The pressed glass is in the form of flat square pieces from 2 inches (5 cm.) on the side, to 6½ inches (16·5 cm.), and in circular convex discs of the various diameters used from 3¼ inches (8 cm.) to 11¼ inches (28·5 cm.). This pressed glass averages about 6 mm. in thickness.

The beginning of this filter development goes back over ten years to the investigations by Dr. Ives on the Daylight Efficiencies of Artificial Illuminants at the Bureau of Standards, Washington, D.C.* These investigations brought out, what has been of inestimable value, the statements in spectro-photometric quantities of daylight, both direct sunlight and the light from the clear blue sky or the so-called north skylight, in addition to statements of the spectral distribution of our ordinary lighting sources at that time. Dr. Ives' later work resulted in combinations of coloured glass and dyed film, first, for the vacuum tungsten lamp in 1911 and in 1913 for the Welsbach mantle; and later, in 1914, with E. J. Brady in the laboratory of the United Gas Improvement Co., Philadelphia, Pa., formulas were determined for pot glasses for use with the Welsbach mantle and also for the gas-filled tungsten lamp.

Dr. Gage, working independently with the chemists of Corning Glass Works, Corning, N.Y., first perfected three separate glasses which were superimposed to form a filter, and shortly after a one piece pot glass which, so far as our investigations have extended during the past three years with hundreds of colour experts and thousands of colours, shades and hues with all kinds of fabric and materials, has satisfied the most exacting that an artificial light has been produced that is actually an improvement over natural daylight. The colour is correct, and it is not variable; it is always available at any time of the day or night, anywhere that electric service reaches. The colours in the glass do not change or fade. An interesting test was made by sending a circular disc of this glass, cut in two, to a location in the State of Arizona, where there is considerable sunlight, and an altitude with more ultraviolet than is present in sunlight at locations where the air strata is more dense. One piece was placed on the roof where it would be in direct sunlight, and the other half wrapped up and kept in a cupboard indoors. The two pieces were compared from time to time, and after a year the test was discontinued as no change could be observed in that time.

In developing a reproduced daylight one difficulty has been to decide the kind of daylight to duplicate. Certain industries and experts have always used the light from the northern sky exposure. Others, less particular, used whatever daylight might be available without considering the direction, the time of day,

* Bulletin of Bureau of Standards, Vol. VI., No. 2, page 231, 1909.

or the possible effect of surrounding buildings. Dr. Ives standardised on the equivalent of the sun at the meridian. With the Gage glass we found a good blue or northern sky equivalent was secured with a given colour concentration, and that with a lesser colour density the noon day sunlight reproduction was available. These two points determined, it was merely necessary to determine a series of density or transmission measurements, and a corresponding numerical designation to enable us to guarantee the delivery of any kind of daylight desired, that is, in so far as these various reproductions may come within the colour range of direct sunlight or clear blue sky or variously proportioned mixtures of each. These "colour numbers," which are purely arbitrary, are engraved on each disc, and range from 100, the sunlight equivalent, to 250 which is beyond the clear blue sky, the latter point being within the range from 200 to 220, depending upon the lumens per watt output and consequent colour of the light of the tungsten filament lamp used. Through this process of absorption in the red end of the spectrum, we also lose in our reflector and the glass filter some of the light which could be used in a reproduced daylight, with the result that the overall proportion of the generated light flux finally effective as a useful daylight equivalent is about 15 per cent. L. J. Jones has shown* that the white light possibilities of the gas filled tungsten lamp are between 35 per cent. and 45 per cent.

This reproduced daylight is of such value to its users that it would be well worth while, even if the losses were 99 per cent. Engineers are quite reconciled to the greater than 90 per-cent. inefficiency of the present production of artificial light with electric incandescent lamps, which are actually very inefficient light-heat engines, and it is not difficult to believe that even at 99 per cent. a light source which is worth from one to ten or even twenty-thousand dollars in a year to its user may cost ten cents an hour to run and be required for an average of two hours per day, a total cost of sixty dollars a year.

In the design of fittings for the use of these filters considerable trouble was encountered due to heat. Glass breakage was frequent, and in some of the earlier experiments the glass stems supporting the filaments in the incandescent lamps softened and bent so as to bring the filament in contact with the side of the bulb. This enormous absorption in the longer wave length or heat end of the spectrum will probably prevent the making of "daylight glass" lamp bulbs unless some other method of filament mounting can be developed, and provided also that other physical obstacles are overcome.

Mr. L. C. Martin, in replying to the discussion, said that his own feeling was that a mere approach to sunlight was very little good. The curve that he had shown for sunlight was supposed to represent noon sunlight in July, which would naturally possess the maximum blue intensity possible for sunlight at the earth's surface. It was not commonly realised that the violets and certain navy-blues are extremely sensitive colours, and unless artificial daylight has received a high correction differences of tint will be found between the colour as seen under this light and under North sky light. This will at once lead to distrust in the performance of the lamp. One great advantage of using the coloured reflectors was that by the introduction of a certain proportion of white or by diluting the colours, the type of correction could be varied in a perfectly definite manner. The efficiency of the unit as compared with an unshaded lamp could be brought to a value greater than 20 or 30 per cent. in this manner, but the accuracy of the correction would suffer at the same time. Only experience can teach the particular demands which will be made upon the lamps and in this connection the remarks communicated by Mr. Luckiesh and Mr. Macbeth are of great interest.

With regard to the permanency of the reflectors every effort was being made to put the unit into the most practical form.

It was interesting to hear that coloured glasses could probably be produced nowadays with greater uniformity than

* I.E.S. Trans., Vol. IX., 1914, page 691.

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had been possible in the past. He had not seen any published data or curves with regard to the *spectra* of other artificial daylights.

With regard to the remarks communicated by Mr. Grills, he could not quite agree that the increase in size of the iris of the eye would produce the differences in illumination on the retina which he suggests. Dr. Lessing raises a point as to the difficulties in the matching of various whites. These were doubtless very great. With regard to the zinc white used for the experiments, this was an unusually good sample such as was employed by Sir William Abney, and its reflection curve was probably extremely uniform. The performance of the Sheringham light on specimens of white had been found to be quite satisfactory as it had been submitted to a very severe test by a paper manufacturer.

The remarks of Mr. Macbeth confirmed the conclusions of the paper as to the possible overall *efficiency* of the daylight units.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Change of Address.

From Monday, February 23rd onwards, the address of the Department of Scientific and Industrial Research will be: 16-18, Old Queen Street, Westminster, S.W.1. (Telephone—Victoria 7940.)

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Official Year Book of the Scientific and Learned Societies of Great Britain and Ireland. (Chas. Griffin and Co., Ltd., London. 1919. *pp.* 336.)

WE have received the 1919 edition of this valuable work of reference, which is doubtless familiar to our readers, and requires no detailed description. The various bodies dealt with are grouped under fourteen main headings, and an index facilitates reference to any particular society. In each case the address, the chief officers, and a list of papers read during the year 1919 is given. The number of bodies to be recorded is now large and it is gratifying to find in this volume evidence that the amount of scientific work has not diminished as a result of the war but has even expanded.

Memorandum on Solid Lubricants (issued by the Advisory Council of the Department of Scientific and Industrial Research, Bulletin No. 4. 1920. 6*d. net. pp.* 28).

THIS bulletin, prepared by a Committee of the Department, constitutes a useful survey of solid lubricants. Such materials as graphite (natural and artificial), talc, mica, sulphur, white lead, etc., on whose properties little information is forthcoming, are analysed, and their various applications for worm gear, steam cylinders and valves, etc., are discussed.

Electric Lighting in the Home by Leon Gaster and J. S. Dow. (Sir Isaac Pitman and Sons, Ltd., London.) 1920. 6*d. net. pp.* 31.)

THIS little booklet, devoted to domestic lighting, is intended to form the first of a series of readable publications dealing with various aspects of illumination in a popular manner. The information is conveyed in the form of a dialogue between the lighting expert and the lady of the home. After a short preliminary conversation on the general principles of lighting each portion of the home is studied in turn and hints are given on the choice of lamps and fixtures and their arrangements in each case. At intervals sketches, showing good and bad arrangements of lights, are included. Finally, a brief analysis of the lighting consumption of the various rooms in a typical middle-class home, and the probable amount of the lighting bill, is provided.

LISTS OF SCIENTIFIC AND TECHNICAL BOOKS.

IT will be recalled that one part of the descriptive catalogue of the British Scientific Products Exhibition organised by the British Science Guild last year was devoted to selected lists of books on science and technology.

We understand that the Guild has now been asked to extend these lists so as to include not only all branches of science but also the chief technical subjects. It has undertaken to do this, and a Committee, of which Sir Richard Gregory is the Chairman, has been appointed to prepare such a catalogue.

The lists will be limited to books of British origin actually in current catalogues of the publishers and obtainable through booksellers in the ordinary way. School books and elementary manuals will not be included, and the general standard will be that of college courses in scientific and technical subjects, or of works' libraries. Each list will be submitted to authorities upon the subject dealt with and in order to secure that no important work is omitted the Committee invites the assistance of anyone interested in its task. Such aid may be afforded by sending to the British Science Guild (6, John Street, Adelphi, London, W.C.2) lists of single titles of suitable works for inclusion in the lists.

CATALOGUES, ETC.

THE new *Lamp Bulb Guide for Car Lighting*, issued by the British Thomson-Houston Co., Ltd., has been brought completely up-to-date and illustrates the expansion of electric lighting for motor-cars. The valuation of voltages, watts, dimensions of lamp-holders, etc., afforded in the handbook, should prove helpful to motor-car users. A feature is the table of lamps for headlights, side-lights and tail-lights in all the chief makes of cars used in the United Kingdom, from which the need for standardisation is apparent. Until greater uniformity can be reached it is at least useful to have available particulars of the types of lamps used with leading types of cars.

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·ELECTRICITY· ·ACETYLENE·

The ILLUMINATING ENGINEER

·OIL· ·GAS·

Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
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EDITORIAL.

Illumination in Mines and Miners' Eyesight.

The mining industry of this country has been prominently before the public eye during recent years, and any circumstances which materially affect the health of workers and the efficiency of work are naturally of national importance. The discussion on "Lighting Conditions in Mines, with special reference to the Eyesight of Miners," opened by Dr. T. Lister Llewellyn, at the meeting of the Illuminating Engineering Society, on February 24th, was therefore most opportune. Dr. Llewellyn is well known as a leading authority on this special subject, and his book on Miners' Nystagmus is the standard work of reference. As the first Tyndall Mining Student he did much valuable work, and the facts that he adduces furnish a striking indication of the great influence of lighting conditions in mines on the welfare of the operators. The meeting was very well attended by eminent ophthalmic surgeons, experts on miners' lamps, and others having experience of colliery work, who came from all parts of the country to take part in the discussion. The Society was also particularly fortunate in having the co-operation of the Council of British Ophthalmologists and the Ophthalmological Section of the Royal Society of Medicine at this joint gathering of oculists, mining engineers and lighting experts.

An excellent opportunity was thus afforded for the discussion of this subject, and the account of the proceedings published in this issue contains many supplementary contributions received from other authorities who were unable to be present.

THE EFFECT OF INADEQUATE ILLUMINATION ON MINERS' EYESIGHT.

The nature of the light afforded by miners' lamps has an obvious bearing on safety in a mine, and the available illumination enabling the miner to pick his steps and do his work is necessarily very low compared with that available for ordinary industrial operations in factories.

But of even greater importance, possibly, is the effect of prolonged working under these abnormal conditions on the eyesight of miners. Dr. Llewellyn's inquiries include both data on the eyesight of miners and information on the actual working illumination in collieries. The disease known as "miners' nystagmus" has long been regarded as primarily associated with inadequate illumination. The symptoms of this nervous affection of the eyes have been the subject of very careful study by Sir Josiah Court and other authorities in this country, and have also been discussed in great detail by Dr. Llewellyn and Dr. Stassen (of Liege) in their respective works, and while the problem is complicated by various subsidiary effects, there appeared, from the general tone of the discussion, little room for doubt that the abnormal conditions of illumination under which the miner works constitute the primary cause of the disease. This, we observe, is the conclusion also reached by Sir Josiah Court, to whose valuable work reference was made by several speakers in the course of the discussion. The data submitted by Dr. Llewellyn on the existing illumination lead to the inference that the number of cases of nystagmus diminish as more efficient forms of lamps are introduced, though naturally investigations on this point require great care and corroboration. He suggests, however, as the minimum average working illumination be aimed at, a value of one-tenth foot-candle over the whole working area.

There are naturally other points besides the actual working illumination to be considered. Amongst these are the question of glare from the filament or flame of the lamp, the effect of inconvenient shadows cast by the body of the lamp, and the problem, to which Dr. Elworthy devotes special attention, whether the colour of the light may not also be an influential factor to an eye adapted to dark surroundings. It has, for example, been suggested that the miner would benefit by using a lamp with a bulb or chimney tinted slightly yellow, so as to absorb the blue end of the spectrum.

All these are questions that deserve to be threshed out, as also the point raised by Mr. Fudge of the Home Office Miners' Lamps Committee, that whitewashing the galleries is in some cases of benefit in diffusing the light and diminishing excessive contrasts. Seeing that at present the available data relate to pits in so many different districts, and cover very variable periods of work, it is not surprising that apparently conflicting conclusions should be drawn on such matters as the relative advantages in use of electric and oil forms of lamps. Other variable factors that need consideration are the effect of varying conditions of work, the average age of the workers, their previous history and especially if they have undergone experiences (as, for example, in the war) which predispose them to this nervous ailment. It is interesting to observe that workers on day-shifts are (as one might expect) more affected by the disease than those on night-shifts.

Experience in the Mines of Belgium.

In any complete investigation the many variable factors must be borne in mind and a careful record should be kept of the local conditions applying in any particular mine visited. The data presented in the contribution of Dr. Stassen, of Liège, offer an instructive indication of the value of such methods. They related to 14,000 men, about half of whom were examined both before and after their spell of work. Due account is taken of the age of workers, and the special nature of their work. A broad distinction is drawn between those cases in which defective illumination was believed to be the *only* cause of the disease, and those in which there were other special factors to be considered. Dr. Stassen has no doubt that inadequate illumination is the chief factor in causing nystagmus, and presents tables showing how, as lamps of greater illuminating power are used, the percentage of nystagmus becomes less. In the case of groups of workers under observation for years, it was found that when men suffering from nystagmus are removed to comparatively well-lighted surroundings complete recovery is usually only a matter of time.

One other very important fact is that nystagmus is not, as has been supposed, confined to coal mines. It has occurred in iron and zinc mines as well, and its almost complete disappearance from mines of this character is attributed to the spread of better methods of illumination. Of equal interest is the statement made by Dr. Llewellyn, in his reply, that nystagmus is not confined to miners. Thus seamstresses working on urgent orders for dark mourning material have given evidence of the disease, and it seems likely that in a mild form it might be found in other occupations.

A Suggested Joint Inquiry into Lighting Conditions in Mines.

There is thus little doubt as to the relation between inadequate illumination in the prevalence of miners' nystagmus. What is needed is a co-ordinated investigation in this country in order to trace this relation exactly, and ascertain the precise nature of the prejudicial conditions. The next step would be to devise forms of lamps meeting the requirements ; and once these are stated the resources of science should be equal to the task.

There are several points that are essential to the complete success of such an inquiry. It should cover a wide area and should be continued for a sufficient length of time to enable positive conclusions to be drawn as to the effect of any improvement in lighting conditions. It should include the joint collection, on a uniform basis, of data obtained by photometric experts, ophthalmic surgeons and medical men, and it would be desirable for the sake of uniformity, for the researches to be concentrated in a few hands.

We, therefore, welcome the suggestion made by Mr. Bernard Cridland that there should be a Joint Committee appointed to deal with this matter, in which the Illuminating Engineering Society, the Council of British Ophthalmologists and the Royal Society of Medicine should co-operate. This inquiry would form a valuable supplement to the useful work being done by the Committee sitting under the Home Office on Miners' Lamps and we trust that the Home Office, which has already done such excellent service in connecting with the lighting of factories and workshops, will lend its sympathetic support to this investigation.

Industrial Lighting and its relation to Efficiency.

It is now rather more than six years since the writer delivered a paper before the Royal Society of Arts on "The Economic and Hygienic Aspects of Illumination," and at the recent meeting of that Society on March 24th an opportunity was provided of summarising progress during subsequent years. In the year 1913 the Departmental Committee on Lighting in Factories and Workshops had been formed and was carrying on its researches, and even the outbreak of war during the following year was not allowed to interfere with the preparation and issue of its First Interim Report, which appeared in 1915. During the war period much valuable experience was gained regarding the value of good lighting in munitions and other essential forms of work, but the circumstances naturally delayed the carrying into effect of the Committee's recommendation that a general requirement of adequate lighting should be included in the Factory Acts of this country.

In his recent paper, therefore, the writer took the opportunity to suggest that, with the termination of hostilities, the time was ripe for this step. Dr. T. M. Legge, H.M. Chief Medical Inspector of Factories, who opened the discussion, took a sympathetic view of this suggestion and expressed the hope that statutory provision would be introduced in the new Factory Act. We are quite in accord with his forecast that the requirement would be of a general character, leaving freedom for the inclusion of more definite recommendations. The experience of the past ten years has enabled us to form quite a clear general idea of the elements of adequate factory lighting, and these are so well appreciated now that a requirement of proper industrial lighting will be readily acquiesced in. Such questions as the amount of illumination required for the carrying on of different forms of work may safely be left to the joint consideration of lighting experts and the various industries concerned. Thus official action in this matter will follow the traditional method in this country of "Government by Consent."

We should like to take this opportunity of putting on record our great appreciation of the enlightened and sympathetic attitude which the Home Office, and Dr. Legge in particular, have taken towards this question of industrial lighting. The United States, it has been remarked, have profited by our experience during the war, with the result that there are already six States that have adopted legislation on factory lighting. But the deferring of action in this country has been merely an inevitable consequence of war and the delay has not been entirely unfortunate in that it has provided an interval for the need for this requirement to "sink in" and for practical experience of the benefits of good industrial lighting to be gained.

The next step to which we shall look forward is the treatment of industrial illumination on an international basis, in which the Illuminating Engineering Society would gladly take an active part. In the data afforded by Dr. Stassen, a Corresponding Member of the Illuminating Engineering Society, on "Miners' Nystagmus," we have a striking example of the value of exchange of views between authorities in different countries, and we have no doubt that equally serviceable help could be obtained in dealing with lighting requirements in other industries.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

LIGHTING CONDITIONS IN MINES, WITH SPECIAL REFERENCE TO THE EYESIGHT OF MINERS.

(Proceedings at a meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, February 24th, 1920.)

A MEETING of the Illuminating Engineering Society took place at the House of the Royal Society of Arts (18, John Street, Adelphi, W.C.), at 8 p.m., on Tuesday, February 24th, 1920, the Chair being taken by Mr. J. HERBERT PARSONS, C.B.E.

A feature of the meeting was the presence of a number of representatives of the Council of British Ophthalmologists and the Ophthalmological Section of the Royal Society of Medicine, many of whom had come from distant parts of the country to take part in the discussion. Typical forms of miners' lamps were also exhibited by a number of leading firms.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of the following applicants for membership:—

The HON. SECRETARY also read out again the names of applicants for membership announced at the last meeting, who were formally declared members of the Society.*

The CHAIRMAN then called upon Dr. T. LISTER LLEWELLYN to read his paper on **"Lighting Conditions in Mines, with special reference to the Eyesight of Miners"** (see pp. 67–79).

Dr. LLEWELLYN presented comprehensive data showing the amount of light available from miners' lamps as in use previous to 1914, and the corresponding illumination available at the coal-surface. Statistics relating to the eyesight of miners were also summarised, the conclusion being that the prevalence of "miners' nystagmus" is largely due to inadequate illumination, and that a minimum standard of 0·1 foot-candles on

Ordinary Members :—

Mr. V. V. Pass	London Manager of Messrs. Oldham and Sons, 10 Hillfield Road, West Hampstead, N.W.
Mr. F. E. Lamplough ..	Director of Research, Messrs. Chance Bros. and Co., Smethwick, nr. Birmingham.

Associate Member :—

Mr. G. Sheringham ..	Artist, 1, Clanricarde Gardens, Bayswater Road, W.2.

Corresponding Member :—

Mr. L. C. Martin ..	Dept. of Tech. Optics, Imperial College of Science and Technology, S. Kensington.

* ILLUM. ENG., Feb. 1920, p. 25.

the working surface is desirable. It was pointed out that the economic loss involved in cases of nystagmus, which exceeded 6,000 annually, amounted to millions of pounds, and that better methods of illumination were thus amply justified on economic grounds.

Dr. H. S. ELWORTHY, who opened the discussion, likewise presented illumination data, in general agreement with those quoted by Dr. Llewellyn, but also emphasised the importance of colour, as affected both by the nature of the light yielded by the lamp and by the character of the coal-surface from which it was reflected.

In the ensuing discussion, the following took part:—

Dr. J. S. HALDANE, Mr. ROBERT ARMITAGE, M.P., Dr. F. SHUFFLEBOTHAM. Mr. E. FUDGE (Secretary of the Home Office Committee on Miners' Lamps), Mr. J. GEORGE, Mr. HAILWOOD, Dr. D. L. DAVIS, Dr. T. HARRISON BUTLER, Dr. C. F. HARFORD, Mr. V. V. PASS, Dr. W. H. POOLEY, Dr. ETTIE SAYER, Mr. B. CRIDLAND, Mr. A. L. WHITEHEAD, Dr. N. BISHOP HARMAN, and Mr. L. GASTER.

Mr. BERNARD CRIDLAND, as a member of the Council of British Ophthalmologists, expressed the hope that the discussion would lead to the appointment of a Joint Committee, on which both the Illuminating Engineering Society and the medical profession should be represented, in order to study the subject in detail. Mr. L. GASTER, who cordially endorsed this proposition, emphasised the desirability of making simultaneous photometric tests of illumination in mines and inquiries into the eyesight of miners.

The CHAIRMAN, in winding up the discussion, mentioned that a number of written communications from Sir Geo. Berry and others had been received, and requested those whose remarks had been inevitably curtailed owing to limitations of time available for discussion, to extend their contributions in writing.

Dr. LLEWELLYN briefly replied to the discussion, mentioning that he would deal with it in fuller detail in the printed account of the proceedings.

After a vote of thanks had been passed to Dr. Llewellyn and to those who had exhibited lamps, The CHAIRMAN announced that the **next meeting** of the Society would take place at 8 p.m. on **Tuesday, March 30th,** when there would be a discussion on **"Motor-Car Headlights in relation to Traffic Requirements."**

PERSONAL.

WE are informed that Mr. A. P. Trotter retired from the firm of Messrs. Handcock, Dyke and Trotter on March 25th, and we understand that he will be devoting attention to the special subjects in science and engineering with which he is identified from his new address (Greystones, Teffont, Salisbury, Wilts). Mr. Trotter has been associated with the earliest developments in illuminating engineering in this country, and is the author of many masterly works and treatises on photometry and illumination. We feel sure that there will be many who desire to benefit from his long experience and unique knowledge of illumination, and we trust that Mr. Trotter will now be free to enrich our available information by the initiation and publication of further researches on many problems on which fuller data are sorely needed.

LIGHTING CONDITIONS IN MINES, WITH SPECIAL REFERENCE TO THE EYESIGHT OF MINERS.

By T. LISTER LLEWELLYN, M.D., B.S.,
Assistant Physician, North Staffordshire Infirmary.

(Paper delivered at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, February 24th, 1920.)

SYNOPSIS OF CONTENTS.

I.—Lighting Conditions in Mines.

The problem of illumination in the coal mine is complicated by the presence of fire damp, by the rough usage which the lamp selected receives at the hands of the collier and by damage due to falls of roof and coal. The presence of fire-damp will necessitate the retention, at any rate for many years, of the oil safety lamp for testing purposes. The hard usage the lamp gets makes its substantial construction necessary, and the need for protection against falls most unfortunately cuts off all rays directed upwards.

As I have stated in my lecture (1) before the North Staffordshire Branch of the Institute of Mining Engineers the illumination in a coal mine depends on four factors:—

(1) The candlepower of the source of light used.

(2) The distance at which this light has to be placed from the working area.

(3) The surface brightness of the surroundings.

(4) The composition of air in the workings.

(1) *Candlepower of source of light used.*—It seems incredible, but the source of light which gives the highest candlepower at the coal face is the tallow candle! By carefully spreading out the wick two candlepower may be obtained.

If measurements are taken at the coal face the modern oil safety lamp, with the exception of such lamps as the Hailwood combustion lamp, rarely gives one-half candlepower. I do not say that they will not give more, but up to 1914 I had not obtained a higher reading. The modern electric lamp in use gives about one candlepower for eight hours. I have lately seen oil and electric lamps giving two to three candlepower, but they are not yet in use. Measurements of the latest lamps in use will be given below.

The light of both oil and electric lamps is broken up by the standards, and varies considerably according to whether a full or side flame is turned towards the observer. Graph I. shows the variation in the illumination falling on the circumference of a circle of two feet radius at the level of the flame or filament. The readings were taken at equal

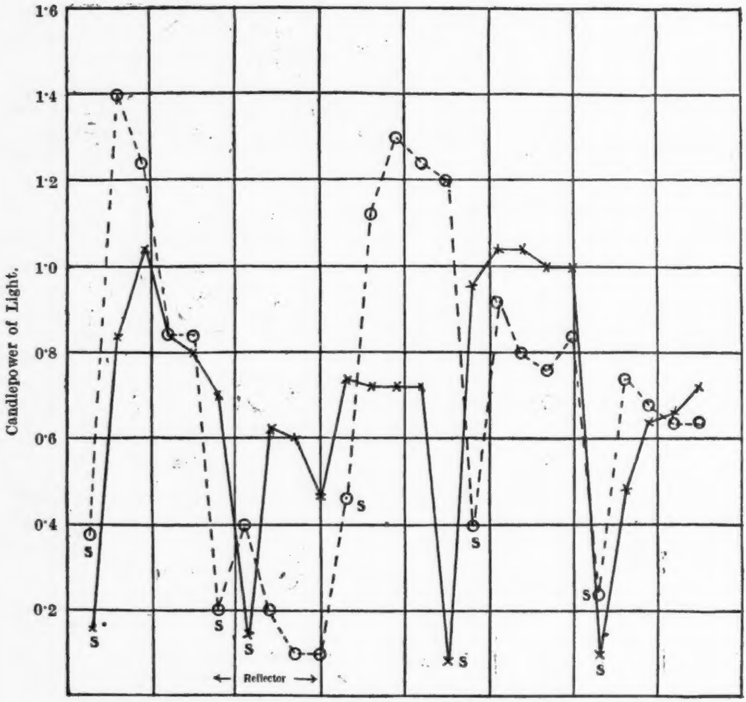

FIG. 1.—Showing variation in candlepower of lamps and effect of standards, S. Equidistant measurements taken at the circumference of a circle 2 ft. in radius × 4 to give candlepower of lamp in a horizontal plane.

---- Hailwood combustion lamp (clean).

—— Oldham electric lamp (after six hours' use).

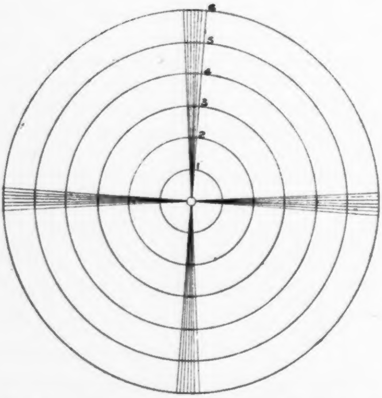

FIG. 2.—Illumination Data for Oldham Lamp.

Area of light in a 6 ft. radius circle, 104·39 sq. ft.
Area of shadow in a 6 ft. radius circle, 8·71 sq. ft.
Ratio of shadow to light 1 : 11·987.

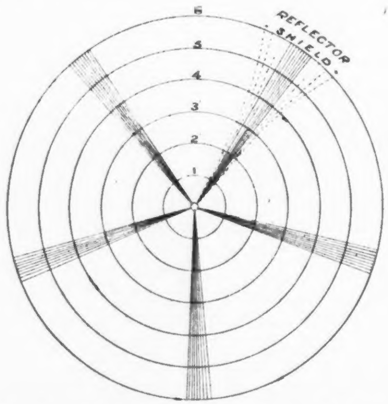

FIG. 3.—Illumination Data for Hailwood Lamp.

Area of Light in a 6 ft. radius circle, 97·15 sq. ft.
Area of Shadow in a 6 ft. radius circle, 15·95 sq. ft.
Ratio of Shadow to Light, 1 : 6·092.

distances and have been multiplied by four to give the candlepower. The electric lamp throws a smaller, but denser shadow than the oil lamp and has four standards to the five of the oil lamp. The amount of light and shadow given by lamps, centrally placed, over a circle of six foot radius is given below :—

	Light.	Shadow.	Ratio Shadow to Light.
Hailwood combustion lamp ..	97·15	15·95	1 : 6·092
Protector oil lamp	104·15	8·93	1 : 11·658
Oldham electric lamp	104·39	8·71	1 : 11·987
Ceag electric lamp	105·07	8·03	1 : 13·084

(2) In the safety lamp pit the lamp has to be placed at least two feet away from the swing of the pick. The lamp is often hung on a post and there is a tendency on the part of the miner to leave the lamp fixed. The law of inverse squares and the cosine law come very powerfully into operation.

(3) *The brightness of the surroundings.*—The collier works in surroundings which are either coal or covered with coal dust. Almost all the incident light is absorbed and there is no colour relief.

Coal and coal dust absorb from 86-97 per cent. of all incident light.

(4) *Composition of air in the workings.*—The light of an oil safety lamp diminishes rapidly when the oxygen percentage of the air falls and the presence of moisture has the same effect. A tested oil lamp actually lost 60 per cent. of its candlepower in a poorly ventilated pit. The presence of dust, quite apart from the fouling of the lamp also diminishes the illumination obtained.

Actual measurements at the coal face.

Up to 1914, as a result of a large number of observations in several coal mines the average illumination at the coal face in a safety lamp pit was found to be 0·018 foot-candle; in candle pits the average illumination was 0·09 foot-candle. The readings are given in detail in my book.[2]

Recent measurements.

Through the help of Mr. Turner of the Stafford Coal and Iron Company I am able to give you measurements with the latest lamps in use.

TABLE I.

	Candle-power.	General illumination at coal face in foot-candles.	Illumination on actual working area in foot-candles.	*Cost per lamp per week.	*Cost per candle-power.
				Pence.	Pence.
Hailwood Combustion Oil Lamp	·99	·017‡	·075	4·75†	4·75
Ackroyd and Best Oil Lamp ..	·58	·021	·06	—	—
Protector Oil Lamp	·79	·019	·06	4·125	5·221
Ceag Electric Lamp	·96	·032	·104	4·671	4·865
Oldham Electric Lamp ..	1·12	·045	·113	5·165	4·611

* Figures supplied by Mr. Turner.
† Hire cost only. Labour not included. Figure supplied by Mr. Wain Chatterley, Whitfield Colliery.
‡ Lamp glass smoked.

The measurements given were all taken under the most favourable circumstances as a length of coal face had been cleared for the purpose. There was no dust and all the lamps were fresh and clean and in the case of the electric lamps freshly charged. Six lamps of each of the five varieties mentioned below were used. The lamps were hung on the same nails and the coal face was marked with chalk to insure that the readings would be taken at the same place. The lamps were tested in the order given. The lamps were placed

on the assumption that four holers and two loaders were working in the drift. The readings from one of the loaders' lamps give the average general illumination at the coal face, the readings from the holers' lamps give the illumination on the area actually being holed. Owing to the favourable conditions the figures are higher than they would be in actual practice. The average candlepower of the lamps is also given. One Ceag

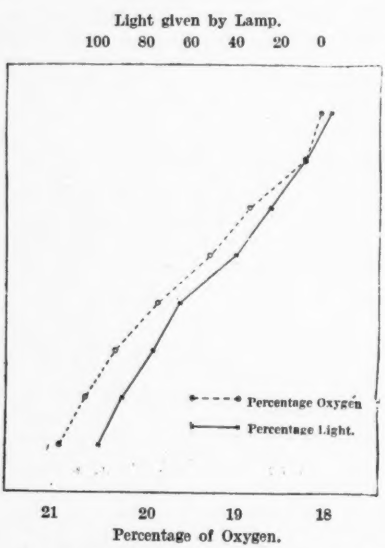

FIG. 4.—Light given by Lamp. Graph of observations (Haldane and Llewellyn), Trans. Mining Engineers, Vol. XLIV., p. 267; "The Effects of Deficiency of Oxygen on the light of a Safety Lamp.")

lamp gave the best light 1·4 candlepower, but the general average of the Oldham lamp was higher. It is interesting to note that the illumination at the coal face given by the oil lamps does not compare favourably with the candlepower of the lamp. This is partly accounted for by the greater extent of the shadows thrown by the lamp standards.

These readings should be compared with others taken recently in another pit.

Colliers top holing in a dusty seam at end of shift :—

Two Ceag electric lamps, average candle power, 0·62.

Illumination on area worked in foot-candles, 0·03.

Colliers getting coal in same seam, end of shift :—

One Ceag electric lamp candlepower, ·8.

One Clanny oil lamp candlepower, ·36.

Lamps over 8 feet away from the coal face illumination at coal face less than 0·01 foot-candle.

Miscellaneous readings.

Well-lit pit bottom. Half-watt electric lamps :—

	Foot-candle.
Inset	0·9
Snapframe	0·4
Main intake	0·2
Collier ripping top	0·018
Collier setting timbers	0·04
Repairer lamp on neck wedging hole in roof	0·05
Timberman notching arm	0·035
Haulier spragging off in parting, lamp in hand	0·06

II.—Physiological Considerations.

The effect of feeble illumination on the eye has always been of great interest to physiologists. Parsons (3) in his paper on "Scotopia or Vision in Dull Illumination" discusses this question fully. With the exception of the manufacture and packing of some specially sensitive photographic plates in darkness no industry is carried out in such feeble illumination as that of coal mining. Let us take some of the signs and symptoms of miners' nystagmus and see if they throw any light on the problem of vision in dull illumination.

Loss of sight.

One of the commonest and often the first symptom is loss of sight, especially marked at night time or in the early morning, that is in feeble light. Men with normal refraction are often unable to read more than 6/36 in the acute stages of the attack. Of 1,121 cases of miners' nystagmus only 103 could read 6/6. I have always looked upon an increase in visual acuity as a favourable prognostic sign. Cridland (4) describes a contraction of the fields of vision for

colour in the acute stages of the disease and a return to normal in convalescence.

Intolerance of bright light.

This symptom is often very marked. In miners' nystagmus then both extremes, bright illumination and dull illumination cause trouble. In the normal person the eye can adapt itself within very wide limits of intensity. In miners' nystagmus the range is limited and there is a special failure for adaptation in feeble illumination. Stassen (5) lays stress in the sudden changes from light to darkness and from darkness to light. In my book (page 114) I say: "Failure of dark adaptation may quite well be the ultimate cause of miners' nystagmus."

Oscillation of the eyes.

Is this characteristic sign of the disease due to imperfect fixation or to fatigue of the oculo-motor centres? In disordered action of the heart, so commonly found in soldiers, and in respiratory trouble due to poison gas there is a neurasthenia of the regulating mechanism in the central nervous system. In both of these conditions fatigue is readily induced and brings about results quite out of proportion to the increased work done. Does working in a dull illumination set up a corresponding fatigue?

Is the ocular movement due to imperfect fixation? The perifoveal region

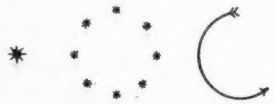

FIG. 5.—Diagrammatic representation of (A) localised central fixation in good illumination at one definite circumscribed area of the retina —the fovea; (B) indefinite perifoveal fixation in dull illumination, all areas of equal value with resulting tendency to movement of the eye in a circular direction, producing (C) the typical rotatory oscillation of the eyes in miners' nystagmus.

of the retina is more sensitive than the foveal for dull illumination. For accurate fixation in good light the object is brought to a focus on the fovea, a definitely circumscribed and specially sensitive area of the retina. If the perifoveal area is used one point is as good as another, and an area of equally sensitive points could be found in a circle, say ten degrees from the fovea. The object may be focussed on any one of these points or on one point after another. If so a tendency to a circular or wheel-like motion of the eye might be set up, and it is a wheel-like movement which is the typical form of oscillation found in miners' nystagmus. Lancaster (10) says that work in deficient light demands an amount of fixation greatly in excess of that called for under ordinary circumstances. Edridge Green (6) says that the movement of the eyes is in the interests of vision.

Tilting of head.

The backward inclination of the head, which is a most characteristic sign of the disease, is in my opinion the result of an attempt to get the eyes in a position of maximum stability, convergence and depression, and at the same time to direct the line of vision forward.

Colour relief.

What is the bearing of absence of contrast or colour relief? Is Elworthy (7) right when he lays the greatest stress on the lack of colour relief or are light absorption and feebleness of illumination the chief factors?

Seasonal prevalence.

Why, as Dransart, (8) Elworthy, (7) Ohm (9) and myself (2) have pointed out, should nystagmus be more common in the winter months? Ohm accepts my explanation that in winter the absence of sunlight (coal workers in the old days rarely saw the sun except on Sundays) interferes with the normal formation of pigment in the retinal cells. Stassen (5) says that nystagmus is commoner among men working by day. Think of the colourless plant striving to grow in the cellar and of the nystagmus of albinoes. I think also that miners' nystagmus is commoner in men with fair hair and light coloured eyes.

Glare.

Although glare is generally associated with light of great intensity, in the low illumination of a coal mine any direct rays of light which fall into the eye

FIG. 7.—Setting a pair of Timbers.

produce inconvenience, amounting in the case of the nystagmic worker, to discomfort or even pain. Many colliers also work in a reclining position with the lamp at their feet, so that the light shines obliquely into their eyes. It is known that the effect of glare is increased when the source of light has a black background and diminished when a white reflector is used. Very few colliers will work at the coal face with a reflector as the amount of working area illuminated is too small necessitating frequent changes in the position of the lamp. Mr. Turner of the Stafford Company gave a man working on a coal cutter a bull's eye miners' rescue lamp. The man refused to use the lamp after the first day, his reason being that he had to keep changing the position of the lamp continually. Would it be possible, however, by the use of a very large reflector with a matt surface to give a diffused light over a comparatively large area and so avoid glare ?

Quality of light.

It has been suggested by Nicholls that the eye has developed itself to be most sensitive to yellow light. (Quoted

FIG. 6.—Ripping Top.

FIG. 8.—Middle Holing.

FIG. 9.—Bottom Holing.

TYPICAL POSITIONS ASSUMED BY THE MINER AT WORK.

by Trotter "Illumination," page 173.) Given equal candlepower, up to five candlepower, are the yellow rays of the candle or oil lamp more restful to the eyes than the "hard" white electric light? What would be the effect on candlepower of a coloured screen in front of an electric lamp? Men suffering from miners' nystagmus have complained of the glare of the electric lamp, but it is a well established fact that men, after failure with oil lamps, have been able to continue when given electric lamps. I do not think myself that the question of hardness should be allowed to influence the more vital question of candlepower.

III.—The Effect of Dull Illumination on the Eyesight of Miners.

(1) *Injury.*

Miners from the nature of their work are very subject to injuries of the eye. In the same way as the tattooing of the skin by coal dust indicates his calling so do the corneal scars, so frequently seen in old miners, tell of old injuries received. Although the injury to the eyes can only be indirectly attributed to bad illumination, the difficulty of attending promptly to the foreign body makes the prognosis in these cases bad, and loss of the eye frequently follows a comparatively trivial injury. In an investigation of the factors concerned in the causation of industrial accidents Dr. Vernon ([11]) found that accidents to the eye due to foreign bodies were from 7–27 per cent. more numerable in the night than in the day. In 269, or 18 per cent. of my cases there was a distinct connection between the history of an accident to the eye and the onset of nystagmus.

(2) *Disease.*

In my opinion the dominating factor in the production of miners' nystagmus is the low illumination found both in the open light and safety lamp coal mine. The arguments in favour of this contention are given at length in my book but may be briefly indicated here :—

(1) Of 1,450 consecutive cases of miners' nystagmus, 1,439 had worked with safety lamps, 1,415 almost entirely, and only 11 men with candles alone.

(2) As a result of an investigation carried out in the Rhymney Valley, where I saw every case of nystagmus, tested the lamps at each colliery and took photometric readings of the light actually falling on the coal face in the various pits the following tables are put forward :

TABLE II.

	Relative percentage of cases of nystagmus to men employed.	Average candlepower of illuminant.	Average illumination in foot-candles at coal face.
Safety lamp pits	6·3	·35	·018 or 1
Candle pits	1	1	·09 or 5

TABLE III.

	Percentage of nystagmus to men employed.	Candlepower clean lamps.	Candlepower dirty lamps.
Pit A	2·00	·235	·22
B	1·57	·27	·2
C	·66	·33	·25
D	·56	·4	·28
E	·42	·42	·27

Nystagmus is practically unknown in the purely naked light districts of Somerset and the Forest of Dean, and is rare in the open light pits of South Wales. In 1910, Scotland, where open light pits are common, had only one quarter of the number of cases of nystagmus as compared with England and Wales taking into consideration the number of men employed. Holing is common in these pits. Of my 1,450 cases over 50 per cent. had done no holing.

Ohm says: Wherever the Wolf benzine lamp is used the disease is not prevalent.

Stassen (5) has recently issued some interesting statistics which support this view. His results are given in the table below.

supported by experimental work came to the following conclusions :—

The effects of unsatisfactory illumination are—

(A) Accidents. Increased prevalence.

(B) Damage to eyesight and health.

"There is a general impression that unsatisfactory lighting is, in various ways, prejudicial to health."

(C) Diminished output. Generally admitted.

If these results are found in the comparatively good illumination of factories, how much more should they be found in the admittedly bad illumination of the coal mine.

TABLE IV.

Mode of Lighting.	Luminosity in Heffner units.		Influence on Nystagmus.		
	Beginning of shift.	End of shift.	Grave cases per 10,000.	Serious cases per 1,000.	No. of cases to % of workers on day shift.
Oil Safety Lamps.. ..	0·50	0·28	35	57	31
Benzine Lamps	1·01	0·80	12	44	21
Candles and Naked Lamps	0·7	0·7	0	13	28
Electric Lamps	1·75–2	$1\frac{1}{2}$–$1\frac{3}{4}$	8	12	15·4
Acetylene Lamps	8–15	8–15	0	0	0

IV.—Economic Factors.

We are by this time agreed, I hope, that the illumination in the safety lamp coal mine is insufficient. Three considerations stand out—

(1) What benefits may be expected with an increased illumination ;

(2) Will these benefits justify the increased cost ;

(3) Results obtained from increased illumination.

(1) *Benefits to be expected.*—The Departmental Committee on Lighting in Factories (1915) after a very thorough examination of evidence,

Incidence of Accident and Industrial Disease.—Let us see first what accident and industrial disease cost the coal owners.

(A) *Accidents.*

The figures quoted are taken from the blue books "Statistics of Compensation" last published in 1914 for the year 1913.

In 1913, 195,387 accidents occurred in the mining industry of Great Britain. For the years 1909-1913 inclusive, the average cost of compensation per person employed was 22s. With the present 75 per cent. increase in the rate of payment this figure will be correspondingly increased. From 1909-1913 the cost of compensation rose yearly, and it is

probable that for 1920 the average cost per person employed will be over £2.

Official returns state that in 1919, 1,113 fatal accidents, causing 1,176 deaths, took place in the mines of Great Britain.

How many of these accidents, both trivial and fatal, might have been prevented with better illumination ?

It is alleged, and quite justly alleged, that many accidents are due to carelessness on the part of the workmen, but might not increased illumination lessen the incidence of these accidents In my official capacity I see thousands of accidents every year and I have often been struck by the history given by the men. I have often felt that so little separates the occurrence from the non-occurrence of many of the smaller accidents which mount up so in the aggregate and cause much loss of time. Quite trivial accidents lead to serious consequences. A stiff finger may throw a man out of work for months. The more serious accidents generally occur from falls of roof at the coal face or in the main roads from insufficient spragging of the loads. It is commonsense to say that, with a better light especially with a lamp that can be tilted without fear, the examination of the roof for the treacherous cracks which indicate the coming fall will be facilitated.

Out of 3,333 consecutive accidents in one mining district 3,057 occurred underground. The coal face was responsible for 52·27 per cent., the haulage roads for 45·6 per cent., and the shaft and pit bottom for the rest—2·13 per cent.

(B) *Industrial disease.*

In the paper read at Stoke I stated that over 6,000 men had been disabled every year since 1913 from miners' nystagmus and that the cost to the country, not to the industry, was one million pounds a year. The paper was reprinted in the leading colliery journals and the subject of a leading article in one journal. No adverse criticism was made on the figures which may then be taken as approximately correct.

The average age at failure in my cases was 40 years. The services of able-bodied men of 40 then may be lost to the State when they should have twenty years of working life before them. We may say that accident and industrial disease cost the colliery proprietors two million a year and the State much more.

(C) *Output.*

If you conserve your man power by diminishing the incidence of accident and disease you will necessarily increase the output. As a direct result of increased illumination you should have an increased output.

(2) *Cost of increased illumination.*—A commercial proposition ?

Quite apart from the moral obligation of the coal owner to alleviate the conditions under which his employees work I hold that the expense incurred in increasing the illumination is sound commercially. I am sure the colliery owners would be only too willing to introduce new installations if they were only sure of obtaining a satisfactory lamp. In a discussion ([12]) last month on a paper on safety lamps by Mr. James Jackson before the Lancashire Branch of the National Association of Colliery Managers, Mr. A. Miller said " A point that had struck him was that they were using the same lamps as they did 30 years ago, a fact which was no credit to the mining community generally—it was sufficient if they got a light which was good and could burn for ten hours. That was what was required, and the sooner the inventive minds in the country turned their attention in that direction, and the sooner the owners let makers know they were prepared to pay for it, because it would be one of the cheapest things they could have, the better it would be for the mining community."

The electric lamp costs from ½d.–1d. a week more than the oil lamp, but the original cost is much higher.

The cost of the oil lamp is generally given at 3½d. per lamp per week. The cost of the electric lamp varies very much. Mr. Johnson estimates the cost of the electric lamp used at the Mossfield Colliery at about 2½d. per lamp per week. Figures quoted by lamp manufacturers, including cost of lamp, show the cost to vary from 0·79—0·82 of a penny per shift without current or labour. Upkeep

costs may vary from 1d. per lamp per week in the first year to 3d. in the third year when renewals and purchase of duplicate parts are required.

I think the lamp of the future will be the electric lamp and already large numbers are being installed. One firm claims to have nearly 200,000 of its lamps in use, including installations of 12,000 and 15,000 lamps to two companies.

Results of increased illumination.

I have shown you the magnitude of the subject and you will ask if I have any figures to support the contention that increased illumination diminishes the incidence of disease and accident and increases output.

(1) In the open light pit nystagmus is rare, in the safety lamp pit the disease is common. I have shown that the illumination in an open light pit is five times that of a safety lamp pit. No comparison can be made between these pits from the point of view of accident.

(2) In my own district the Mossfield Colliery Company owns two pits a couple of miles apart in which the same seam is worked under exactly similar conditions. Six years ago nystagmus was equally common in both pits and the Manager, Mr. Caleb Johnson, started to introduce electric lamps into one of the pits. I went down one of the pits (Pit A) and took photometric readings six years ago and I have repeated these tests in the second pit (Pit B) last week. The readings, together with Mr. Johnson's figures as to output, incidence of disease and accident are given in the table below:—

I include some figures from South Wales where the introduction of electric lamps has been carried out on a larger scale.

Dr. Phillips has kindly sent me the number of fresh cases of nystagmus occurring during the last five years among ten thousand colliers working for two companies. In one company oil lamps alone are used and the yearly incidence of nystagmus is 0·57; in the second company nearly 50 per cent. of the lamps used are electric and the incidence of the disease is 0·175. Dr. Phillips writes:—"The incidence of nystagmus is undoubtedly greater where oil lamps only are used. I am also convinced that the presence of nystagmus is responsible for a large number of accidents." Dr. Elworthy says that for the years 1909–1911 the percentage of nystagmus among underground workers in his district was 0·71. With improved ventilation and the introduction of over 6,000 electric lamps the incidence fell to 0·1 in 1919.

In the *Ophthalmoscope*, Vol. XIII., Mr. Coulter, of Newport, quotes a letter from the Manager of a group of Welsh Collieries employing 2,600 men. The letter is slightly abbreviated:—

"Sir,

"We had had 102 cases of nystagmus certified, but a far greater number of men have appealed to us for electric lamps. Electric lamps on a small scale were introduced June, 1912. A number of cases working on surface have returned to work underground with electric lamps. From experience gained we have come to conclusion—

TABLE V.

	Lamps used C.P.	Illumination at coal face in foot-candles.	Cost of Nystagmus per ton.	Shifts lost from accident.	Output per person per shift.
Pit A	Oil 0·25	0·015	$\frac{3}{5}$d.	1 in 23	100
Pit B	Electric 0·62	0·023	negligible	1 in 54	105

These measurements were all taken at the end of the shift in a very dusty seam.

"1st.—That insufficient light causes nystagmus.

"2nd.—That the introduction of electric lamps has enabled scores of our workmen to continue working underground.

"3rd.—That the use of an electric lamp is a good preventative of nystagmus."

V.—Standard of Illumination Required.

Nystagmus is common in oil safety lamp pits and rare in candle pits. If then we compare the light given by the oil safety lamp in general use with that of the candle, we may be able to set up a standard of minimum illumination. In the following table the value of the candle has been taken as one wherever possible.

TABLE VI.

	Candle.	Safety Lamp.
Distance from coal face	1	2–6 times as far
Candle-power	1	0·5
Spherical candlepower	1	0·22
Area illuminated..	1	0·5
Illumination at coal face	1	0·2
Mobility	Can be placed anywhere	Fixed
Constancy..	Remains constant	May lose 30%
Relighting	Easy	Difficult
Attention required	Nil	Frequent

I suggest the standard to be aimed at be that of the candle pit—an average illumination of one-tenth of a foot-candle—over the whole working area. A cap lamp of one candle would give a greater illumination than this, but the ordinary lamp placed at least twice as far from the face as a candle must be of three to four candlepower to give the same result.

Last week I was able to test underground this Oldham electric cap lamp, which I now show you. While walking to the coal face I wore the lamp in my belt, and the whole of the travelling road was well lit up. I have never picked my way so easily in a pit. At the coal face the lamp was worn in the cap and the following measurements were taken:—

Candlepower	0·95 Foot-candle.
Drilling shot hole	0·1*
Working ratchet machine ..	0·55
Examination of roof ..	0·25–0·28
Holing—	
Kneeling	0·18
Semi-reclining position ..	0·18
Full reclining position, coal undercut two foot three inches	0·08

Compare the last readings given with the average general illumination of an oil safety lamp coal face 0·018 foot-candle and with the results given in Table I.

The most striking features about the lamp are the large area and uniformity of illumination and the absence of shadows. The old Japanese proverb that the darkest place is just below the candlestick fortunately remains true and the workers' eyes are consequently protected from all glare.

If the lamp is held two foot three inches from a blank wall an area 15 feet wide and 10 feet high is illuminated. The weight of the lamp is $2\frac{3}{4}$ lbs., the lamp itself and twelve inches of cable weigh seven ounces, a small weight for men who have been used to wearing a steel hat.

Examination of the roof can be carried out very quickly and efficiently.

*A Hailwood combustion lamp placed in nearest position gave 0·02 foot-candle.

I was very impressed with the trial and predict a great future for a lamp of this character. The advantage of taking your light with you wherever you go and always having it most advantageously placed makes the cap lamp about six to eight times as efficient as an ordinary oil safety lamp and two to three times as efficient as the electric lamps in present day use. I suggest the lamp be given a trial in the first place in the haulage roads where the lamp has to be continually carried about and where 20 per cent. of all oil lamps are extinguished each shift. These cap lamps are used very extensively in America and their safety has been vouched for by the United States Bureau of Mines.

The miner's lamp.

The miner's lamp should be safe, foolproof and of simple construction. It should be of substantial make and easily taken to pieces for repair. If not built to stand the rough usage it will undoubtedly receive, no repeat orders will be obtained, and discredit will be thrown on the industry. A constant steady light for at least eight hours is required. The area illuminated should be as large as possible and few shadows should be thrown. The lamp should be easily re-lighted and require no attention. An easily adjustable and readily removable reflector should be fitted.

The purely technical questions of the relative advantages and disadvantages of the acid and alkaline cells, the high upkeep cost and variability of bulbs and other kindred matters I leave to the makers, but I must call attention to the poor quality of the glass supplied, both to the oil and electric lamp manufacturers. A good light may be quite marred by the poor quality of the lamp glass.

Lamp-room organisation.

Under this heading I only wish to call attention to the importance of the lamp-room, which should be the show place of the colliery and under the care of a thoroughly capable and experienced man. The proper cleaning of lamps, especially oil lamps, is of great importance and machine brushes should be fitted. Lamps cannot be cleaned by hand without undue multiplication of the staff.

Miners' Lamp Committee.

At the present moment there is, sitting in London, a Committee to inquire into the improvement of the miners' lamp. Let us assume for the moment that they will decide that, although the lamps of the present day show great improvement, the standard reached is not sufficient for them to recommend the general introduction of any one lamp. What will they do? Will they leave the future of the lamp in the hands of manufacturers, laying down a standard to be aimed at, or will they throw the onus on the coal industry? This brings up the question of research and the advisability or otherwise of apportioning a sum of money for this end.

I hope it will be the privilege of this meeting, which Mr. Gaster has striven to make as representative as possible, after pointing out the urgent need for increased illumination in our coal mines, to indicate the methods for obtaining this end. I myself am full of hope, as the coalowners, who, as a class, have always the best interest of their employees at heart, now realise the importance of the question. I think that in this twentieth year of the twentieth century the long continued supremacy of the farthing dip will be finally ended.

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LIGHTING CONDITIONS IN MINES, WITH SPECIAL REFERENCE TO THE EYESIGHT OF MINERS (*DISCUSSION*).

Special Contribution by H. S. ELWORTHY, F.R.C.S.

To illuminate coal mines satisfactorily, what is required is a safety lamp that will give sufficient light, and of a suitable quality, to enable the miner to work without getting the disease known as miner's nystagmus.

This is a disease of the nervous system, and not one of the eye only.

As mines become older, and the coal further away from the fresh air shaft, the air becomes more deoxydised, and oil lamps give less light. It must not be forgotten that if the air is so bad that a lamp will not burn properly, it is bad for the man to work in it, and simply to provide a better light and leave him to work in bad air is not a complete remedy—it is only a partial one. The conditions in coal mines are different from those in any other occupation.

The colour of coal is nearly black, containing from 2½ to 3½ per cent. of white, and the slack is sometimes as black, but more often slightly lighter.

The colour relief is the average of these taken together. Here is a card showing the colour of one of our pits, it contains between 2½ and 3 per cent. of white.

I will give three examples of conditions found in steam coal pits :—

	Candle-power of lamp.	Colour relief.	Surface bright-ness.	Distance lamps apart.
Pit 1 ..	·1	2·7	·00058	15 ft. 6 in.
Pit 2 ..	·19	2·55	·00055	18 ft.
Pit 3 ..	·12	3·3	·0004	8 ft. 6 in.

Here men work in surroundings with only 3 per cent. of colour, or less, with lamps from 8 to 15 feet apart, giving from ·1 to ·2 candlepower, and where the coal only reflects about half a thousandth part of a foot-candle, and that light appears as small glistening white or bluish-white specks. No red or yellow is seen. The roof in some places is black and glassy, and is faintly radioactive. Here is a photograph taken by placing lead letters on a plate and the piece of roof resting on them.

If a man works 20 years with his head close under such a roof, it is just possible that it may have some effect on his nervous system, but I rather doubt it.

Concerning nystagmus, a paper of mine was published in the *British Medical Journal* for November 19th, 1910, in which I suggested that more colour should be introduced into mines, and that the men should have more daylight; and in another paper which appeared in the *Ophthalmoscope* for December, 1912, it was shown in the reprint that the incidence of nystagmus was inversely proportional to the chromophotic index of the mine, and that I had found no nystagmus when this index was as high as 500.

The chromophotic index is made up of three factors—the candlepower of the lamp, the surface brightness of the coal, and the colour relief. We cannot alter the surface brightness to any extent, but we can alter the colour relief by passing the posts through a light wash, or by colouring the roof, and we can alter the candlepower either by improving the ventilation or by introducing electric lamps.

So far colliery owners do not seem to fancy introducing colour, and the problems of ventilation are very difficult, so they prefer to increase the candlepower of the lamps.

In the Ebbw Vale collieries for the years 1909, 10 and 11 our percentage of nystagmus among underground workers was ·71, the general percentage for South Wales was ·17, and for the Anthracite Field, ·019, so we had four times as much as the average for South Wales. Since then certain changes have been made.

A new fan was put into one mine,

haulage engines are now worked by compressed air, so more gets into the mines.

Electric lamps were introduced in 1914, first the C.E.A.G., and these have now been replaced by the Oldham lamp. We have over 6,000 of them now.

In 1914 we had ·73 of nystagmus, and the next year it had dropped to ·22. Then the war came and "summer time" was introduced, and then shorter hours, so the men got more daylight.

A number of our colliers went to the war, and their places were taken by new men who would not be likely to get nystagmus for years.

For last year, 1919, our percentage had dropped to ·1, the general rate for South Wales was ·28, and for the Anthracite Field ·16, so we had less than half the average.

In looking over my papers for 1913 I find two calculations to determine the minimum candlepower required to bring two of our worst pits up to the safety margin, that is to say, a chromophotic index of 500, and in both cases the candlepower required was ·9.

This coincides very closely with Dr. Llewellyn's results, as he suggests that it should be one candlepower.

But let me make it quite clear that when I say a miner's lamp should be one candlepower I mean that the light that passes through the thick outer glass is fully equal to a standard candle. I certainly do not mean that the little electric bulb may give one candlepower, but when the outer glass is put on the light is a good deal less. To call such a lamp one candlepower is misleading.

Now, as to the quality of the light. With an oil lamp, one sees a rich yellow light with a tinge of red in it when in fresh air, but on arriving at the coal face, where the candlepower has become reduced, say from ·5 to ·1, a very noticeable change is to be seen. Although the flame is practically the same size, it has become distinctly paler. Part of the red and yellow rays have disappeared, and the flame looks pale bluish-white. On returning to the surface the yellow and red appear again. In places where the coal reflected a large proportion of blue, with this pale bluish light, I noticed a sensation of strain and discomfort in the eyes, but in places where the coal did not reflect much blue it was not noticed. In one of these bluish pits where the roof had been whitewashed for experiment, I and others noticed a distinct sense of relief to the eyes when passing under it.

The light that affects the eye of a miner is that which is reflected into it from the coal. That is the important point.

Experiments.

In order to find out what rays were most irritating to the eyes, I got some light filters which roughly divide the spectrum into three equal parts, red, green and blue.

With a small lamp in a dark box, a ray of light was passed through these filters, through an aperture 1 mm. in diameter, thus showing a small spot of light in a dark room.

Thirty people were tested by these lights.

After looking at the spot of light for a short time, the visual purple in the retina where the light falls on it becomes exhausted, and the eyes unconsciously move in order to focus it on other parts of the retina and so enable it to be seen, and this is what happens in nystagmus.

These experiments led me to conclude that the red and green caused the most active movements, but in the case of the blue the spot of light quickly disappeared, to reappear and disappear again. It seemed to exhaust the visual purple more than the other colours, but caused less active movements.

If, however, all red rays were excluded by using a blue-green glass, or a methyl violet filter, the movements were active, but the tendency to disappear remained.

In the case of a man who was rather subject to watery eyes, the effect was remarkable. The red and green gave the ordinary movements, but no trouble; but the blue brought on profuse lachrymation, and after about five minutes his lids were swollen up, and he looked as if he were suffering from a severe cold.

Another man experienced smarting in the eyes when methyl violet was used.

It seems to me evident that the rays from the violet end of the spectrum—

which may include ultra-violet rays—have an exhausting and irritating effect on the eye, and an excess of them is to be carefully avoided in any lamp used in a mine.

In cases of incurable nystagmus I have known men to suffer severe pain in the eyes and head for years after they had left work, and the pain often came on at night, when they were not using the eyes, so they got up and tramped about the house because they could not sleep for pain.

This did not seem to be due to errors of refraction, because supplying new spectacles did not cure it.

The condition must surely be brought about by something other than the mere working in a defective light. It seems suggestive of something in the nature of an X-ray or ultra-violet burn, and I have a strong suspicion that there is a distinct relationship between incurable nystagmus and the rays from the violet end of the spectrum.

In my series of 200 cases, there were 10 incurable, and eight out of these worked in pits where the light was pale and the coal reflected a large proportion of blue.

By using these light filters, and a corresponding filter over the eyepiece of a photometer, it is possible for a sensitive eye to make a rough analysis of various lights, and of the light reflected from different sorts of coal.

To give a few examples :—

	Blue %	Green %	Red %
Tallow candle ..	5·53	28·84	67·63
Marsaut oil lamp ..	7·2	22·2	70·6
Carbon filament electric	6·64	26·63	66·63
C.E.A.G. electric ..	13·63	31·13	55·24
Oldham electric ..	17·0	32·0	51·0*

Here you see the metallic filament lamp give out twice as much blue as the carbon, or tallow candle.

*This is the result of a single analysis, commencing with blue and ending with red. The reading for blue is therefore higher than it should be. During the observations the candle power of the lamp fell from 0·55 to 0·475 at the end. A correct reading would be obtained by commencing with the red and ending with the blue, and averaging the results, several observations being made both ways.

Light reflected from coals :—

	Blue %	Green %	Red %
House coal, Forest of Dean	4·5	13·3	82·1
Anthracite	4·7	23·9	71·4
Welsh steam coal..	9·0	26·0	65·0
Ditto ..	9·12	33·43	57·45

Here you see the steam coal reflects twice as much blue as the anthracite or the house coal, and it is in the steam coal pits that we get the most nystagmus.

From these remarks it might appear that the problem of miners' nystagmus is comparatively simple, but to me it is exceedingly complicated and puzzling. My observations have been few, and confined to one locality, and it would be unwise to generalise from them unless confirmed by others.

Only once have I noticed an oil lamp look yellow at the coal face, and then the conditions were probably abnormal. The intake airway was partially flooded that day, so we had to go in by the air exit. While going in there was a fall of roof partially blocking the way, but a few hours before there had been a fall just before the last working place was reached, completely blocking it up. By the time we got there a small passage had been made large enough for us to crawl through with my apparatus.

Here the flame of the lamp was distinctly yellow, and from its appearance I judged it to be ·4 or ·5 cp. but on measuring it found it was only ·12. Yet the flame was not small.

On analysis it was found to contain blue 5·2, green 21·4, red 73·4, which is very much what it would have been on the surface. As you know, if a small oil lamp is turned down till it gives only say ·2 cp., it looks bluish. Such a flame gave on analysis: blue 9·5, green 26·9, red 63·6, so that an explanation of the yellow flame seen in the mine can only be arrived at by knowing the composition of the air. In other parts of that pit the flame was pale. The presence of certain gases may have something to do with nystagmus. Much research is required before we can profess to know all about it, and very great care should be taken in illuminating, lest a light be

introduced which for a time seems beneficial, but which in the course of years may easily result in a greatly increased output of nystagmus of an incurable type.

If you experts on illumination were called in to improve the lighting of a room with very dark and dingy paper, I think the first thing you would do would be to order a lighter one, that would reflect the light better. It is the same principle in coal mines. If, instead of working with a tenth of a candlepower in coal, the men were working in chalk, there would be no nystagmus. They would have a better illumination, because chalk reflects say from 90 to 95 per cent. of light, but coal less than 9 per cent., so that in chalk the tenth of a candle would be equivalent to more than a full candle in a coal mine.

It is not so much the amount of light thrown on the surface that matters, but rather the amount reflected back, and that is why I hold that the cause of nystagmus is the absence of colour in coal, because, for that reason it does not reflect back the light. (It only reflects as much as it does on account of its crystalline structure. If it were not crystalline it would only reflect from 2 to 3 per cent. of light.)

The three things I want to see introduced into coal mines are : (1) colour ; (2) more fresh air ; and (3) a proper amount of light of a suitable quality, for I quite agree that a fifth or a tenth of a candlepower is a ridiculously small amount of light to work with. If you are about to establish a standard of quantity, I wish you also to establish a standard of quality. My ideal is the carbon filament, or the tallow candle. A proper proportion of yellow, and not too much violet.

I desire to acknowledge that I received the idea of the spot of light moving in a dark room from Dr. Edridge-Green, and the method of making an analysis of light from your Hon. Assistant Secretary, Mr. J. S. Dow.

After the presentation of Dr. Elworthy's communication THE CHAIRMAN called upon Dr. J. S. HALDANE to continue the discussion.

Dr. J. S. HALDANE said that Dr. Elworthy had referred to the effect of the air in mines. He (Dr. Haldane) thought that this had probably little to do with the question of nystagmus. On the whole the air in mines was surprisingly pure and as a rule the miner worked in a good atmosphere. Analysis had shown that the air in all big, well-ventilated mines was very pure. There was often some firedamp (methane) present, but this gas was not poisonous, and he himself had breathed an 80 per cent. mixture of artificial air containing methane instead of nitrogen. The mixture was substantially the same as ordinary air, and many animals had been kept in it for a long time.

Nystagmus interested him very much in relation to other forms of so-called localised neurasthenia, of which they had seen many examples in connection with the war. He had had to deal particularly with neurasthenia of the nerve centres governing breathing and the respiratory centres. A condition was met in which breathing, instead of being of the ordinary deep and fairly slow type, became rapid, shallow and inefficient after exercise. Such a condition might be due to overwork or overstrain, or might arise through gassing or some infectious disease.

Now similar disturbances of the nerve centres controlling other functions, for example the pulse, occurred as manifestations of local neurasthenia. Photophobia after gassing was common. There was fatigue of some sort connected with the effort made by the miner to see in the darkness and this led, apparently, to a chronic nervous condition. He would like to ascertain whether nystagmus could be produced experimentally, as the fatigue of the respiratory system or of the heart could be produced. He hoped that the Chairman might be able to tell them something on this point.

He (Dr. Haldane) had acted as an intermediary in bringing Dr. Llewellyn

in touch with the President of the Society, Mr. Trotter, who had aided him in connection with photometric matters. Just after the last explosion in Wales, in which practically all the officials were killed, Dr. Llewellyn had come down and went round with the inspector and he had been much impressed by his knowledge of colliery matters, and particularly of the subject of nystagmus. The result was that he became the first Tyndall Mining Student. Sir Josiah Court, of Chesterfield, had also done a great deal of work on the relation between lighting and nystagmus. A great deal of detailed information on the illumination available was needed and that they had obtained, to a great extent, from Dr. Llewellyn.

Mr. ROBERT ARMITAGE, M.P., said it would be remembered that the Government offered a prize of £1,000 in 1911 for the best electric lamp. It was given (anonymously then, but it was now public property) by Sir Arthur Markham. The specification was drawn up from the colliery point of view by Mr. Charles Rhodes, and from the electrical point of view by Mr. C. H. Merz, and they decided upon the prizes given. A very large number of lamps came in from all parts of the world, even from Japan, and the Ceag lamp got a prize of £600, and a good many others prizes of £50 apiece. Orders were then placed for about 10,000 Ceag lamps, and these had been in use since 1912, and they were beginning now to get facts which, he thought, would be good enough in a short time to warrant the Government taking a much more active part in this work. The adoption of those lamps had resulted in a reduction in nystagmus and in accidents, and the men were able to get away from the pit bottom much sooner than with the oil lamp, as they got their eyesight quicker. In the Eccleston mine, one of the largest in the Yorkshire district, there were 2,667 men employed in 1912, and there were 459 accidents and 12 cases of nystagmus. That was the year before the Ceag lamps were introduced. In 1919 there were 2,058 men, 256 accidents and seven cases of nystagmus. The cases of nystagmus varied considerably. In the Brodsworth, another colliery in the same neighbourhood, there were 2,464 men in 1912, 439 accidents and 11 cases of nystagmus. In 1919 there were 2,911 men, 419 accidents and five cases of nystagmus. In another colliery which was sunk about the time the Ceag lamps came in, and in which they never had oil lamps, they had from four to six cases of nystagmus a year. The cost of running the Ceag lamp worked out at 1·29d. per shift.

Dr. FRANK SHUFFLEBOTHAM remarked that it seemed to him that it was only within the last year or two—indeed, one might say within the last month or two—that there had been any systematic effort made to come to grips with this disease and check the incidence of it. It was a most hopeful sign that the Illuminating Engineering Society had joined forces with the Royal Society of Medicine and the Council of British Ophthalmologists in endeavouring to combat the disease.

He thought that the number of cases of miners' nystagmus in this country at the present time was probably even greater than that estimated by Dr. Llewellyn. In addition to the reported and certified cases, there were many others, which, possibly because they did not reach the most acute form, were not reported. He felt sure that the Illuminating Engineering Society and the other bodies he had mentioned were anxious to do everything possible to overcome the disease, and he would therefore like to emphasise the importance of regarding it from the general physiological standpoint and not merely as a disease of the eyes. Hitherto, the treatment of these cases had been largely in the hands of eye specialists, whereas the affection of the eyes was only one symptom of a general nervous disease. Other symptoms which were equally distressing and which caused incapacity to work had been insufficiently studied, and he hoped that this would be borne in mind in any further investigations that might be made. He suggested that the treatment of miners' nystagmus should be undertaken on the medical side of hospitals and not simply in the eye department. Of course, it was necessary that the eyes should receive every attention, but it was equally important for the general nervous symptoms not to be neglected.

Mr. E. FUDGE said he was Secretary of the Government Committee which had been at work for about nine months with the chief object of improving the light-giving power of the miners' lamp. They found there was no broad road along which rapid advance was possible. The lamp makers had served the collieries well, had taken a great interest in the subject, and had done a lot of pure scientific research with a view to improving the safety lamp, and they had improved it. But there were definite limits to an increase in light giving power of the safety lamp as constructed at present.

Taking the electric lamp first, the governing limit was the weight. The candlepower could be increased by increasing the weight of the lamp, but this was already about as much as the weight of a miners' lamp could properly be. The lighting power might be increased by increasing the efficiency of the battery or by eliminating the large amount of shadow. A great proportion of the light was cut off by the pillars and the top and bottom of the lamp. Then there were minor improvements such as the rating and efficiency of the bulbs, taking into account their life, and improvements in quality of glass and small details of that sort, but until a genius came along with a new accumulator or a new method of construction, improvement must be for the present in points of detail.

In flame lamps also, the possibilities of improving the light on the present principles of construction were limited. There were now lamps that would give anything up to 2½ candlepower, but these were necessarily more complicated in design and more liable to go wrong and to go out than the old Marsaut lamp, for instance, and there was also the rather serious defect of overheating, which was exceedingly difficult to get over. Some of the experimental lamps which the Committee had now in hand got too hot to hold after burning a short time, especially in sluggish air. There was no safe acetylene lamp at present, but there might be possibilities in that direction; and he agreed with Dr. Llewellyn that there were great possibilities in the electric cap lamp because in principle it makes a much more effective use than the ordinary lamp of the necessarily very limited amount of light available. He thought Dr. Llewellyn had said the black coal face absorbed anything up to 90 per cent. of light. As regards this, the question for the practical man of the pit was whether the white washing which was done to some extent in a good number of pits, could be carried further. Near or at the coal face the practical difficulties he knew, were great, but the beneficial results which might be obtained were very great too. The effective illumination would be increased much more by even a limited amount of whitewashing than by doubling the candlepower of the lamps used. As the Committee, of which he was Secretary, evolved experimental types of lamps (and in this he included the electric cap lamp) they proposed, provided the lamps were found safe under laboratory tests, to test their suitability in the pits; and if there was any colliery agent or manager who would co-operate with the Committee in that work or in the matter of extended whitewashing, he would be glad to get into touch with him.

Mr. E. A. HAILWOOD said it occurred to him, when he heard of the statements of the alleged benefits to be obtained from the electric lamp, that it was singular that if the 69,341 electric lamps now in use in the Yorkshire Inspection Division were giving such good results, how it came about that the Manager of the Yorkshire Coal Owners' Mutual Indemnity Society, when giving evidence before the Compensation Committee in October, 1919, said the number of cases of nystagmus had advanced from 30 in 1907 to 515 in 1918. It led one to wonder whether the electric lamp was the remedy that it was claimed to be. At December, 1918, there were 156,521 electric lamps in use in the country and 90,200 of the combustion type. Dr. Llewellyn gave the candlepower of the combustion type as ·99. On a previous occasion he gave 1·5 to commence with and 1·3 after six hours; that and more could be regularly produced in the combustion lamp, but it must be borne in mind that the lamps were used roughly by the miners, and one could not always

give the maximum to them. In that particular case there was a narrow slot through which the flame passed for bringing the air on to the flame, but subsequently the slots were opened out because proper attention could not be got from the lamproom, and the miner appeared not to realise that the lamp was worth the few moments' attention when he got to the coal face so as to get the full possible benefit.

Assuming that there were 156,521 electric lamps giving apparently 1 candle-power and 90,200 combustion type, making 246,721 lamps supposed to be giving 1 c.p., that left 499,985 lamps of other kinds in use in the country. With such big percentage of lamps giving the high candlepower one would think the total number of cases would go down considerably if *illumination* was the principal remedy. According to Dr. Llewellyn's figures the number of cases now was 6,000, but everyone knew that since the war the cases were jumping up in a most peculiar manner. His firm had about 192,000 lamps of all kinds in the country —about one-third of the total—and about 90,200 of them were combustion type. His firm wrote to a number of their customers for particulars of cases of nystagmus. There were 136 pits in one group replied (using partly combustion type and partly double-gauze oil lamps), the full benefit of the combustion type lamps could not yet be ascertained because they had had to send some here and some there to meet the demands. In 41 pits there were no cases of nystagmus. Twenty-three pits reported no increase from October, 1918, to January, 1920. Twenty-six pits reported reductions of cases in the same period, and forty-six pits reported an increase. What astonished him was the great variations in the number of cases at pits within a mile or two. In one group of pits belonging to one company there were 2,835 lamps, having ninety cases of nystagmus; in another group, 1,058 lamps, there were only two cases; another had 2,477 lamps and six cases, and another 1,100 oil lamps and about 1,000 electric lamps, and had 26 cases. If *illumination* were the principal factor, why were not the results more similar? and how did it happen that 41 pits using the same oil lamps should be free from nystagmus?

Illumination might be important, but he felt certain there were other things affecting the question. Men who had worked in dusty pits thought the irritation of the eyes and nose by the dust had some effect. Men came out of the pits soaking with perspiration and went out into the cold weather or sat in trams or trains and did not muffle themselves up or put warm coats on, and if the nystagmus were a nervous disease as the doctors said, this practice might contribute to the trouble.

His own feeling was that even small traces of gas in the atmosphere had some effect on the nervous system, and no doubt on the eyes as he had noticed particularly on one occasion that in a very gassy part of the pit that the gas produced a sense of dizziness and affected his eyesight, and it should be borne in mind when considering the comparisons made by Dr. Llewellyn that metalliferous pits are *free from gas*, and if it should be that gas had some effect on the system there is no wonder that the cases of nystagmus are nil or very rare in such mines. In naked-light coal mines it is possible for a *small* amount of *gas* to be hanging about, and as there are some cases of nystagmus in these mines they seem to support the theory of gas having effect on the eyesight. In safety lamp mines naturally one expects to regularly meet more gas and hence more insistent effect on the constitution, and it seemed to him that the possibility of gas is one of the causes for the variations in quantity of cases of nystagmus mentioned above.

It is a common sight now to see children wearing spectacles which have been ordered by the school doctor. When these children subsequently go down the mine they leave off their spectacles and thus throw a strain on their eyes, which may develop into nystagmus.

In Dr. Llewellyn's estimate of the expense of Nystagmus to the country, his largest figure was for the alleged "loss of output," but to the writer's mind this was an incorrect assumption, as Dr. Llewellyn overlooked the fact that at the present moment there are more miners employed than at any previous time, and that probably in most cases

there are as many men available as the pit can conveniently engage or handle; so that if the whole of the 6,000 men were available it is doubtful whether there would be any increased output or, if any, it would be only a small amount as the existing men working alongside skilled men are no doubt quite competent to turn out (within a fraction) the amount of coal which would have been turned out by the 6,000 other men. In view, therefore, of the doubt as to whether electric lamps would produce the benefit anticipated by Dr. Llewellyn, it would seem advisable to go far more closely into the question before involving the country in an outlay of probably two to three million pounds which would be the cost of installing electric lamps and their charging and manipulating equipment at the various collieries of this country, and especially at a time when it is so necessary to economise in every possible direction so as to get the nation back on to "its feet."

The Cap Lamp, exhibited and approved by Dr. Llewellyn, might have been passed by the American Government and might be in use in America, but it did not by any means follow that it was a suitable thing for mines in this country. It was obvious that if the current was conveyed from a battery strapped to a man's waist to a lamp fixed on his cap the conductors, being flexible, as they must be, were liable to be tampered with and there was a possibility of an exposed light being obtained in the mine. It was well known that the cables could be tampered with and a cigarette be lit from the light so obtained, furthermore, apart altogether from the difficulties which would be experienced in persuading the British workman to have a special hat with a special flap to carry the hat-lamp, and to carry a somewhat heavy battery about with him the *whole of the day*, strapped to his waist, he thought that if Dr. Llewellyn considered how easy it is to create an explosion by cracking an electric bulb in a gas mixture he would scarcely advocate the placing of an electric bulb on the most dangerous part of the human body, viz., *the head*, where it was so liable to get smashed from coming into contact with various things, and particularly at the coal face, *where the gas is usually found*. The electrical resistance of the long cable reduced the candle power and taxed the battery power.

He noticed that in one of the pictures thrown on the screen an oil lamp was presented as coming out at the end of a shift, and all smeared with mud. This was not quite fair to the oil lamp, as the condition would only occur in a wet pit, and then only to a proportion of the lamps.

If bad illumination had increased the number of cases of Nystagmus, probably one of the most important recent causes was the enforcing of flame lamps being fitted with double-gauzes just about the commencement of the war, as obviously lamps with double-gauzes could not burn so freely as with single-gauzes. He contended that the single-gauze lamp had an enormous margin of safety and that the long experience gained had proved that a very large number of collieries in this country could very well have been left alone without being penalised with the double-gauze and its resultant reduced illumination.

In view of the efforts put forward under most difficult conditions to produce miners' flame lamps (his own firm having for example spent large sums of money in this way) he naturally disagreed with the statement made by Mr. Jackson before the Lancashire Branch of the National Association of Colliery Managers, wherein he implied that there had been no improvements in flame lamps for the last thirty years. He felt sure that Dr. Llewellyn would agree that this was not a correct view to take.

The same applied to the remarks by Mr. Caleb Johnson, of Mossfield Colliery, as it should be clearly understood that his comparison is between an electric lamp and an *old* type of oil lamp which was not by any means the latest type of oil lamp. Furthermore, at the present moment flame lampmakers were suffering in regard to the illumination given by the flame lamps owing to the glass difficulty, as, to meet the shortage of glasses, it had been necessary for some while to use glass which was tinted and which cut off a good deal of the illumination; but of course as materials and facilities increased this would be put right and the clear glass be again got into use when the full

candlepower of the lamps would be available.

They were all anxious to help to solve the problem of Nystagmus, but he did not think matters were helped by depreciating the flame lamp and ignoring the stringent conditions under which flame lampmakers had to work, or the useful purpose they could serve if the conditions were made more reasonable.

(*Added* :—The useful purpose they already did serve has been illustrated by an incident that occurred since the meeting was held, at the Ponthenry Mine in the Gwendraeth Valley, South Wales, on Friday, 27th February. A large blower of gas burst into the workings and extinguished the whole of the flame lamps (which were of the Hailwood type) and thus forced the men to at once get out of the workings, which all did with the exception of one man. Had the men had electric lamps, or a substantial proportion of electric lamps, it is conceivable that they would have attempted to have gone on working when perhaps another few minutes would have killed the lot, so that it is obvious that in looking for a remedy for Nystagmus care must be taken not to run into greater dangers).

Mr. JOHN GEORGE said he spoke as a lamp maker's representative. He had been brought up from a boy in the pits to the position of colliery manager. They had now the electric lamp, but he made bold to say that the oil safety lamp had never moved one inch from the principles given them by Humphry Davy. He agreed with the point that had been raised that the electric safety lamp hurt the eyes, for the first day or so. Dr. Llewellyn spoke about the men rarely seeing the sun. When he first went down the pit he was down from 6 a.m. to 6 p.m. That bore out Dr. Llewellyn's statement. He worked in an open lamp pit and his eyes became sore when he came out if the sun was shining, but it was not the sun, but the long confinement in the dark pit that caused the soreness, and if men suffered at first with the electric lamps it was due to the indifferent light in which they had previously worked. In two districts in Lanarkshire, an open lamp district and a safety lamp district, the men's faces in each of these respective districts were different altogether. The blinking of the eyes which indicated the first stages of nystagmus was quite common in the safety lamp district. Increased combustion in lamps meant that oxygen was being used up and giving off a double supply of carbon dioxide and the result of that with a thousand oil lamps could be imagined. The miners themselves were a lot to blame with regard to nystagmus. They hung up the safety lamp and were afraid to touch it in case it gave out, and the whole place was left in the dark. Where Ceag lamps had been installed accidents had been reduced and he knew of an instance where men who could have the best oil lamps free of charge preferred to pay ninepence a week for an electric lamp.

Dr. D. L. DAVIS, Cardiff, said that improvement in the lighting conditions in mines must be regarded as an urgent necessity, apart altogether from the question of nystagmus. From the available statistics it seems probable, indeed almost certain, that the number of men hindered from working through nystagmus will be materially diminished as a result of the improvement in lighting.

But, nevertheless, he could not accept the theory that miner's nystagmus was the direct result of defective lighting. It had never yet been shown that defective lighting had produced nystagmus in any other occupation, such as for instance, workers in the manufacture of ultra sensitive photographic plates. Many theories had been propounded to explain the occurrence of the oscillation of the eyes in cases of nystagmus, some plausible, but all unproven.

The nature of nystagmus might be briefly summarised as follows: The subject complained that when he came up from the pit (particularly if it happened to be night), the lights all danced in front of him and caused so much dazzling that he was unable to see properly. In slight cases this got better after he had been up some time, and the dancing of lights and dazzling was usually less troublesome by day unless it happened to be a very bright day. In marked and severe cases the dazzling was so

great as to be almost blinding, and was associated with great nervous prostration, the man appearing to the most casual observer as a miserable, nervous wreck.

On examination the following conditions were found :—

(A) Nystagmus; or rapid rotatory movements of the eyes especially when they are directed upwards. (B) Blepharospasm or rapid and forcible blinking of the eyelids. (C) Tremor of the head which can easily be felt or brought out by laying one's hand on the bent head and asking the man to try and extend the head while the movement is forcibly resisted by the examiner. (D) Photophobia (intolerance of light). (E) Night blindness.

These were the classical signs of the disease, but the following were also present in the great majority of cases :—

(F) Fine tremor of the hands when they are extended with outstretched fingers—a tremor very like that seen in exophthalmic goitre or graves disease. (G) Increased reflexes such as the knee jerk. (H) Contracted visual fields. (I) Altered mental conditions—for example, these people often become irritable or morose.

These symptoms and signs were in effect all attributable to a disturbance of the nervous mechanism of the body. What could produce such wide spread changes? He could not accept deficient lighting as being the prime factor in the production of the disease. It was without doubt, he believed, due to some form of chronic poisoning, and this poison was probably to be found in the gaseous exhalations from the coal; it might be the heavy hydrocarbons or other exhalations of which we at present had no knowledge.

What were the proofs which could be adduced in favour of this statement?

(1) Those mines which were least "gassy" and in which the naked light could be used were precisely those in which nystagmus was rare. He believed this was due, not to the better lighting conditions, but to the diminished amount of gaseous exhalations; in other words the same conditions which led to the impunity with which the naked light could be used explains the absence of nystagmus.

(2) Those who were working at the face of the coal, where ventilation was least perfect, were much more frequently attacked than those working in other parts such as hauliers, etc.

(3) It had been shown by some observers that nystagmus was more prevalent in some workings and at certain seasons than others. Might not this due to differences in the rate of the diffusion of the noxious gas caused, perhaps, by atmospheric pressure changes?

(4) Nystagmus was rare in those who had worked only a short time underground, but when it did occur in such circumstances the nervous symptoms were very prominent as though in such cases the man was particularly vulnerable to the poison. Usually the disease only manifested itself in those who had been working for years; in other words, it was a form of chronic poisoning with occasional instances of a more acute type.

(5) Lastly, the visual fields were contracted.

Mr. Cridland had shown that in a high percentage of cases the visual fields showed a definite concentric contraction, sometimes amounting to 50 or 60 per cent., and that the fields to blue and red were more contracted in proportion to the white. He (Dr. Davis) had for some time past, and for another purpose, been carrying on an investigation into the visual fields in cases of chronic poisoning caused by the formation of pus or matter in various parts of the body; such for instance as might occur in an abscess of the bone. He was struck by the fact that in such cases of chronic auto-intoxication (as it was called), marked concentric contraction of the visual fields was present and that the field to colours was proportionately more contracted than that for white; in other words, the fields in miners' nystagmus were similar to those occurring in other forms of poisoning.

On the theory that miners' nystagmus is a neurosis produced by a chronic poisoning, which was brought forward by Mr. Harrison Butler at the Oxford

Ophthalmological Congress in 1916—how could we explain the fact that the number of cases of nystagmus reported diminished in the better-lighted mines? He thought it could be explained in the following way. It was known that the movements of the eyes cause less inconvenience to the miner under moderate good diffuse daylight. As the intensity of the light was reduced or increased so his symptoms increased. They were always worse at twilight and at night. In the daylight the nystagmus had not disappeared, only the resulting symptoms are less disturbing. This was probably due to the fact that the man was better able to focus with the macular region by daylight, whereas in dim light the visual purple was ill-formed and the macular region did not get supplied with a proper amount to actuate the percipient elements; consequently owing to the inability to fix centrally the movements become more rapid and produce more severe symptoms.

So too then, when underground, if the nystagmic miner is supplied with a better light, provided no glare is present, he would be able to carry on his work *in spite of* his nystagmus. Improved lighting, as he had already said, would probably diminish the number of men who are absent from work on account of nystagmus, but it had yet to be proved that nystagmus was actually cured by increasing the illumination of the surface on which the miner was working. He regarded miners' nystagmus as due to a chronic poisoning of the central nervous system, but the actual movements of the eye as being increased by defective illumination. Improvement in the lighting would add to the comfort and greater efficiency of the miner, and so lead to increased production.

Finally, he would ask the question: "Is miners' nystagmus on the increase?" He was told by some colliery officials that it was. If so might it not be correlated with the ever increasing distance at which the men have to work from the pit head and consequently increased difficulties in ventilation? He would, in conclusion, suggest that there was a wide field for chemical research into the characters of the air at the face of the coal where the men have to work.

Mr. T. Harrison Butler (Leeds) said it was unreasonable to expect better lighting to effect any immediate reduction in the number of cases of nystagmus. The disease might take from 10 to 25 years to develop. It would be 10 years before the curve of nystagmus would show a material fall. It was conceivable that a brilliant light would at first rather increase the cases of nystagmus. It would produce photophobia in the case of a man used to working with one-tenth candlepower, and that factor would make it appear that the increased illumination had no good effect at first. Mr. Shufflebotham said it was only this year that nystagmus had obtained official recognition. He differed from him in regard to that. He introduced a discussion on the subject at the Oxford Congress of Ophthalmology in 1912, and it was largely owing to the discussion at that meeting that the Government scheduled lid-twitching, apart from general nystagmus, as a condition for which the miner could claim compensation.

Dr. C. F. Harford said that his interest in "Miners' Nystagmus" had been derived from contact with cases of the disease who came under his care when, as a medical officer in the R.A.M.C., he was responsible for ophthalmic work in connection with the 21st Division at the Central Military Hospital, Aylesbury. He recorded his observations on these cases in a paper which appeared in the *British Medical Journal*, of March 4th, 1916, under the title "Visual Neurosis of Miners in their relation to Military Service." The most serious of these cases was a gunner who had apparently passed the visual tests for the Army but who, when admitted to hospital was almost blind and a hopeless invalid, shewing all the characteristic signs of the disease which had been clearly set forth in Dr. Lister Llewellyn's well-known monograph, except that he never succeeded in discovering any nystagmus. These cases convinced him that the disease was a complicated affection of the nervous system, which demanded the attention of the neurologist quite as much as the ophthalmologist, and that it was one of far-reaching importance, scientifically as well as practically.

Dr. Christie Reid, of Nottingham, wrote: "I was much struck when in the mining district of N.E. France, round Bruay (P. de Calais) with the complete ignorance of the disease, though from conversation with the miners I ascertained that their methods of getting coal were much the same as ours. I wrote, on my return here, to the manager of the Bruay Mines and asked him if any did suffer. He said they used to be familiar with the disease, but that since the introduction of the electric lamps (hand) the disease had been eliminated and was practically unknown."

Now if N.E. France could supply these lamps why could not our colliery authorities do likewise? Those who have studied the question were, he thought, now all agreed that the poor light leading to feeble yellow-spot fixation was the prime exciting cause of ocular instability.

If it was a question of £ s. d., he thought it could easily be proved that the extra cost of the lamps would be more than counterbalanced by the enormous saving from the elimination of the disease. Now what was being done? A few pits in various parts had adopted the electric lamp (hand), but the most he had been able to do here (Notts and Derby coalfield) had been to secure that a few individuals suffering from severe nystagmus be allowed such lamps. This, as Dr. Reid said, was "tinkering" with the subject. Whatever subsidiary causes there might be, and there were many, which combined to bring on the disease, such as accidents to the head, errors of refraction, etc., there could be no reasonable doubt that defective illumination was the primary difficulty.

Inconsistency in statistics might be due to the following conditions:—

1. That the diagnosis was often difficult.

2. That with better knowledge more cases were recognised than in past years.

3. That many incipient cases which had arisen from bad illumination in the past might persist even under more favourable conditions or might develop due to circumstances which lowered the general health.

We had arrived then at the conclusion that the disease was preventible, and we must go a step further and determine that it must be prevented. The time would surely come when it would be regarded in the same light as such an industrial ailment as phossy-jaw and might be practically stamped out. To this end we must set ourselves as representing different points of view, and if so would surely be successful.

Mr. V. V. Pass (London Manager of Messrs. Oldham and Son) referred to the difficulties, to which Mr. Fudge had alluded, in obtaining a four candle-power lamp. Naturally the weight was the main difficulty, but the possibilities of improvement would be considerably greater if a satisfactory low voltage gas-filled ("half-watt") bulb for use in miners' lamps could be developed.

Added:—I gladly avail myself of the opportunity to give some further particulars of the "Oldham" electric safety lamp exhibited at the meeting:—

(1) *Electric Lamp Maintenance.* From figures submitted by colleries themselves, instances of "Oldham" electric lamp renewal costs may be cited as follows:—

Costs of installing original new lamps and equipment and renewals required for same, of South Yorks Plant over a period of about four years (January, 1916–October, 1919), including also costs of all new lamps and equipment additions from time to time, but excluding labour and current, ·8d. per lamp per shift. To this report the management attach the following important data:—

Average length of life of positive plates	90 weeks
Average length of life of negative plates	130 „
Number of negative plates not yet changed, which have been working 2 yrs. 7 mths.	250
Number of outer shells replaced by chemical action	0
Number of outer shells replaced by mechanical action	9
Number of new bottoms replaced by chemical action	0
Number of new bottoms replaced by mechanical action	50
Number of outer glasses broken	960
Celluloid box replacements ..	12

South Wales District.—Inclusive renewal costs over a period of 2 years 9 months equal 1·6d. per lamp per week, excluding labour and current (April, 1916–December, 1918).

Staffordshire District.—Renewal costs of our plant over a period of 12 months, January–December, 1919, equals 1·9d. per lamp per shift, including labour.

The above facts it is believed will clearly demonstrate that in the design of the "Oldham" lamp the hitherto difficult problem of acid trouble as understood in the sense of repairs has been entirely eliminated without relinquishing the advantages of the free acid type of accumulator. In the case of miniature pattern "Oldham" electric lamps for special purposes (where the design does not permit of embodying our standard construction of miner's cell), and where plate maintenance is not of paramount importance, the system of solidified acid or packed cells is made use of.

(2) *Lamp Room Handling.* The lamp room equipment includes machinery for rapidly enabling every process of dissembling, assembling and cleaning of lamps and cells to be rapidly effected by a *minimum of unskilled labour,* this also applies to charging and treatment of accumulators. Accordingly, in a well-equipped and properly organised electric lamproom, labour costs come out lower than for a similar number of oil safety lamps.

(3) *Advantages of electric over oil safety lamps.* Having in mind the exhaustive facts contained in Dr. Llewellyn's paper and the recognised statistics of mine accidents where oil as against electrics are used, we consider the extent to which electric lamps have already been adopted offers sufficient proof of the claims made in respect to increased output, reduction of minor accidents, and in underground relighting costs particularly on the roads. Further, and whereas in former cases of colliery explosions the men have been thrown in total darkness, the important advantage with an electric lamp equipped pit would be under such circumstances that whatever ordinary chance the men had of escaping it is reasonable to presume this would be considerably enhanced by their ability to travel at a greater speed. In addition and in the event of say 10 men being entombed, the special design of the lamp would enable illumination being provided for at least 60–70 hours (by using one lamp at a time) even supposing the occurrence took place just at the conclusion of the seven hours' shift; the illumination referred to also representing no loss of available air supply.

In respect to the safety of the electric lamp as against oil; as manufacturers of both, and with full knowledge and respect for what the modern oil lamp will stand, we nevertheless frankly do not consider the respective safety features of the two types will bear comparison, even without taking into consideration the miners', now recognised, preference for the electric, which preference is in many cases made use of at electric lamp pits (to ensure proper handling) by the alternative of the miner being compelled to take an oil lamp. Regarding inability to test for gas with the electric lamp, from our experience we are of opinion the average miner relies entirely on the officials covering this duty, in accord with which collieries using electric lamps we believe find a 10 per cent allowance of oil lamps satisfactorily meets requirements in this respect.

At the same time, we consider it of interest to remark that in connection with the building of "Oldham" gas chambers (which enable any percentage from zero to an explosive mixture being obtained in a few seconds), for training colliery firemen, tests have been carried out with various latest types of single and double glass oil safety lamps which have clearly demonstrated that unless the miner takes the precaution of testing for gas in the correct manner or fails to denote "tailing up" and other signs indicating the presence of a gaseous mixture, it is quite possible for the oil lamp to be burning in a mixture of four to five per cent. of gas without the man being aware of it from casual observation, particularly in the event of smoking or dusting up of the glass having taken place. Considering this point, we venture the opinion that the question of gas testing is in any case entirely a matter for special arrangement and trained officials, in substantiation of which we may record that on the

occasion of his paper, "Methods of Detecting Firedamp in Mines," before the Royal Society of Arts in 1910, the Chairman of the Mines Commission (Sir Henry Cunynhame, K.C.B.), after concluding his demonstration tests with the "Oldham" chamber, specially commended same to the notice of colliery owners.

In submitting the foregoing remarks as being offered without prejudice on our part, we may reiterate being ourselves patentees of a new design two candle-power oil safety lamp intended for officials use. Whilst stating the present type "Oldham" electric safety lamp embodies the results of over 12 years' experience and practical colliery tests, and having in mind reference which is still being made to the results awarded in the open lamp competition held eight years ago, we feel entitled as a matter of interest and in justice to British industry to point out that the "Oldham" H type lamp was not entered in the competition as the basis design of this lamp was not standardised until some time afterwards owing to the constructional features representing an entirely new departure in electric lamp construction, and accordingly necessitating extended practical tests before final adoption could be considered. Comparative tests extending over periods of 12–18 months, two concerns alone in the South Wales district, have between them 27,100 lamps in use, further to which we believe we are strictly correct in stating that of the total number of electric lamps in use in this country practically 50 per cent. of same are now "Oldham" type.

Mr. G. H. Pooley (Ophthalmic Surgeon to the Royal Infirmary, Sheffield) said that he had listened with great interest to the able papers contributed by Drs. Llewellyn and Elworthy. Miner's nystagmus was a curse to the collier and to the colliery companies and the insurance companies, who underwrite the employers' risks under the Workmen's Compensation Act. It was extremely prevalent, thousands of colliers being absent from their work because of it.

As to its causation, the two main theories advanced were those of the late Simeon Snell and Sir Josiah Court of Staveley, the former in 1875 attributing the condition to fatigue of the ocular muscles, analogous to writer's cramp. Sir Josiah Court in 1891 attributed it to faulty illumination.

Dr. Llewellyn's book (1912) gave far more information than had been previously available, and in the main the contentions he put forward had proved to be perfectly correct, in the light of subsequent experience. The Great War had prevented much further research from being undertaken, but out of evil cometh good information, and the result of the military training of colliers had shown :—

(1) That a miner with nystagmus, often with an amount that did not incapacitate him from doing regular work at the coal face, could not see to shoot with accuracy or to march at night.

(2) That the defect frequently became more marked and the incapacity greater some weeks or months after leaving the colliery for military training.

(3) That the result of explosions, shell bursts, etc., was to aggravate the condition considerably.

All of this showed that the condition of latent nystagmus in those men who had all volunteered and were keen to fight progressed to active serious nystagmus, in spite of fresh air and good light. This was not unknown before, as cases occur during a strike, so that the condition must be due to some instability of the cerebral centres caused by :—

(1) Defective illumination under the present conditions of working.

(2) To an unknown extent to the impurities in the atmosphere in which they work, for it is in the outlet air in which the lamp gives a poorer light that the cases of nystagmus most frequently occur, and this impure air is breathed by the men.

Our information was not yet sufficiently full to enable us to estimate the effect of long inhalation of coal gas. This instability, due to long exposure to these conditions, remained latent or in abeyance for a long time, but might become marked at any time when activated by a shock or accident even when the collier had been in favourable conditions for some time.

The best explanation at present was as follows: As the collier worked in such a feeble illumination as to require dark

adaptation of his eyes, his macula (central vision) became a blind spot, and it was the constant rotation of the eyeball to obtain a fresh piece of active retina to see with that caused the particular form of nystagmus which affected miners. This feeble illumination also increased the risk of accident; every collier had in his cornea numerous fine particles of coal tattooed in at his work.

The remedy lay in the better illumination and the better ventilation of mines. The whole system of lighting wanted alteration, so that instead of a mine being one of the darkest places, it might be brilliantly lighted with 60 candlepower lamps, instead of half candlepower ones. If it were possible to use electrically-powered coal-cutters it was not inconceivable that lamps might be worked by similar power; with this and with greatly improved ventilation, so that fresh air was breathed, we might see the last of miner's nystagmus.

If any one could provide the necessary funds to investigate the effects of the outlet air of a mine on the blood of animals and man, some very interesting information might be obtained.

Miss Ettie Sayer said that ten years before the war she had practised with incandescent lamps of 800 candlepower, of a type claimed to yield a yellow light free from blue rays, and had found them of great value in treating cases of lupus, neuritis, etc. People could lie day after day with such a lamp only 14 inches from their eyes and the effect was not irritant but soothing. Such lamps had also been used in cases of iritis. After the outbreak of war such lamps could not be obtained, and it was found that when ordinary tungsten lamps were used in the same way an exposure of a few minutes set up inflammation unless strong protective glasses were used. A carbon filament lamp, which contained relatively more red and yellow and less blue rays, was better than the tungsten lamp but still inferior to the special lamp giving only yellow rays to which she had previously referred.

It occurred to her that in circumstances where the available illumination was very low it might be of importance to exclude the blue and actinic regions of the spectrum.

Mr. Bernard Cridland, F.R.C.S.E., D.O. Oxon., congratulated the Society on dealing with this important topic. Miners nystagmus should be regarded as a disease of the ocular centres of the general nervous system, and little doubt was now entertained that the character of the illumination was the most important factor to be considered.

He trusted that the discussion would not merely be recorded in the transactions of the societies interested, but that a joint committee, on which both the Illuminating Engineering Society and the medical bodies concerned should be represented, would be appointed to conduct a full inquiry into the whole question.

Communicated:—First, may I congratulate Mr. Gaster and the Illuminating Engineering Society on having convened this joint meeting. The subject is a very important one from all points, and it is unfortunate that there has been no opportunity since the discussion at the Oxford Ophthalmological Congress in 1912 for a further interchange of views upon this interesting disease, its causation and prevention. For that, of course, the war is accountable.

Work on the subject has doubtless been carried on meanwhile individually, but not collectively, or with those outside the medical profession, so all the more is it a matter for congratulation that we are here on the invitation of those who can and doubtless will in due course so modify the conditions of work in the mines as to render the incidence of coal miners' nystagmus an insignificant quantity.

The resolution passed at the Oxford Congress was as follows: "That, in the opinion of the Congress, the *character* of the illumination is the *chief* factor in the production of miners' nystagmus," etc., and I think that this is the view now held by all medical men who have the handling of cases of nystagmus and who have studied the disease.

It is noteworthy that the resolution contains the words "character of the illumination," and also "chief factor," and, I think, they were wisely chosen. "Character" comprises not only sufficiency, but actual source, colour, position, etc., all of which are of importance, and, again, "chief factor"

means at once that there may be other factors, although minor ones only. The latter should be kept in mind for it is quite likely that when the ideal illuminant has been produced and has been in use long enough to draw conclusions, we shall still find some cases of nystagmus or some curious modification of the disease for which we shall have to invoke other causes than faulty illumination. It is the latter, however, that we are considering to-night and rightly so, for it is by far the most important.

There are already a good number of statistics on the effects of faulty illumination and improvements in illumination in mines, and if these are not enough many others could be produced which would form a mass of uncontrovertible evidence in favour of the present-day view as to the chief cause of nystagmus. I suppose that the latest published record is that of Dr. Stassen, of Liège, one of whose tables Dr. Llewellyn has given. One point worthy of attention in this table is the reference to acetylene lamps. The figures on this line are those obtained from the iron and zinc mines and are therefore not strictly comparable with those on the other lines of the table. The acetylene lamps used are naked ones with reflectors.

Stassen mentions that he found nine cases of nystagmus amongst 183 workers, but they were of the benign or mild form, and probably existed before the introduction of acetylene lamps, all of which is, of course, in favour of the view held. But I think it right to draw attention to the way the figures are given for otherwise one not knowing would naturally say all that is necessary is to use an acetylene lamp of 8 to 15 candlepower in a coal mine and nystagmus will disappear. I am not aware of the use of an acetylene lamp in a coal mine so far, but I will refer to this later.

There is just one point I should like to ask Dr. Llewellyn and that refers to his observations with regard to seasonal prevalence, namely, that nystagmus is more common in the winter months; does he base his figures on the number of days worked in summer as compared with the number in winter, or simply on the total number of cases reported in summer and winter irrespective of the number of days worked? In the pits producing house coal only the days worked in summer average two a week as compared with four or five in winter (in pre-war time, of course), and there would naturally be less nystagmus. I ask this for information and in no way wish to dispute his very reasonable conclusion.

Dr. Llewellyn has given us his views on "the standards of illumination required," and I am sure we are all in accord with them. He suggests that the standard aimed at should be that of the candle pit. This should, I think, be the lowest standard; I do not think it would be harmful to have what might be regarded as an excess of light provided that it is properly placed. Would it not be possible to introduce one or more lamps of high candlepower in a stall or heading in addition to those of lesser candlepower? The brighter lamps hung high and reflecting downwards would give first of all a better general illumination and would not interfere with the lighting of smaller areas by the smaller lamps. By this means there would be less contrast effects and therefore fewer retinal shocks. The advantage of having peripheral illumination is seen in the effect of working in a room at, say, a desk lit by one lamp only, the rest of the room being in semi-darkness, in such conditions the eyes fatigue more easily than when the room is lit generally in addition.

There are many other points for consideration such as colour, diffusion, and the effect of the ultra-violet rays upon the eyes, all of which I think require careful investigation. But I would here like to ask the Engineering Society if it would not be possible to construct an acetylene lamp of, say, 10 to 15 candlepower with reflectors for use in the mine, self-contained and portable. It should be possible to make it a safety lamp, and the glass could be of the triplex pattern and of Crookes' A or B type. Such a lamp could be used to obtain a general illumination in addition to other smaller, but handier ones.

In conclusion I would ask, sir, whether this important matter is to end by simply recording the discussion in our respective transactions. There is so much investiga-

tion to be done before anything like a definite conclusion can be agreed upon.

I suggest that the first procedure is to have a report drawn up indicating to the Government the necessity for action to be taken in improving the illumination in mines and indicating the lines on which such action should run. Such a report could be drawn up by a joint committee of the Illuminating Engineering Society together with representatives of the medical profession and such other scientists as it may be necessary to include.

From an ophthalmic point of view we have the machinery ready and with great respect to the ophthalmic section of the Royal Society of Medicine I suggest that the Council of British Ophthalmologists as representing British Ophthalmology in general be approached with a view to nominating the medical portion of the joint committee; naturally, their nominations would be in accordance with the custom of the Council in similar matters from amongst those with special knowledge of the subject and not necessarily ophthalmic surgeons.

The drawing up of such a report is, I think, as much as can be expected of voluntary effort, it is not fair or businesslike to expect men to give not only their time and energy, but to find themselves actually out of pocket in working for what will be a national investment when success is achieved. The further burden of actual research must be born by the nation, and those who carry it out should be adequately compensated.

Mr. A. L. WHITEHEAD (Leeds) thought that Dr. Haldane had summed up the situation in one sentence—Nystagmus was essentially due to the efforts made by the miner to carry on his work under disadvantageous conditions. Defective vision due to errors of refraction or any other condition, added to his difficulties, but whatever subsidiary causes were at work, the essential cause was defective illumination. If the illumination could be increased this would go far to counteract any secondary cause.

Dr. Llewellyn's statistics seemed to show that if the light could be increased, even by $\frac{1}{2}$ candlepower, nystagmus would almost be abolished. The head-light supplemented by an adequate reflector would apparently solve the difficulty, if it could be regarded as absolutely safe; and even if the electric hand lamp were used, its efficiency could be much increased by a suitable reflector.

Mr. N. BISHOP HARMAN said that the form of head lamp shown by the author appeared to have some excellent features, but would the long length of flex permit of its use in a dangerous mine? If so, its advantages would outweigh any drawbacks as regards weight.

As regards the causation of nystagmus, he thought that there could be no doubt that inadequate lighting was the most important factor. The papers of Sir Josiah Court, who showed that in safety-lamp mines the disease was prevalent, whereas in mines where candles could be used it was rare, were convincing on this point. To stress secondary factors until the lighting problem was solved was a danger—a red herring across the trail!

He felt that the solution of the problem of lighting demanded something more than improvements in details, which seemed all that was immediately practicable with the ordinary form of miners' lamps. During a visit to the Cavendish Laboratory at Cambridge he saw a form of vapour lamp which could be looked at with comfort for any length of time, and which gave a very diffused light. It seemed desirable to initiate a research with the object of producing some form of vapour lamp, supplied from a battery of small weight, suitable for use in mines.

Mr. LEON GASTER mentioned that a number of valuable communications from Sir George Berry and others had been received and would be included in the printed account of the proceedings. He wished to thank all those who had contributed to the interest of the meeting by exhibiting miners' lamps. They had listened with interest to Mr. Fudge's remarks in regard to the work of the Home Office Committee on Miners' Lamps, of which he is secretary. The Home Office had shown their enterprise in dealing with industrial lighting through the medium of the Departmental Committee appointed to deal with this matter,

and he thought that there was another equally useful field for their activities in connection with illumination in mines.

He welcomed Mr. Cridland's suggestion that there should be a Joint Committee formed to enquire into the whole question of illumination in the mines in relation to the eyesight of miners, and the Illuminating Engineering Society would greatly appreciate the co-operation of the Council of British Ophthalmologists and the Royal Society of Medicine in this work. An essential feature of such an enquiry would be the joint collection, on a uniform basis, of data on illumination and eyesight, collected respectively by photometric experts and ophthalmologists and medical men.

The Committee already sitting under the Home Office on miners' lamps would doubtless do most valuable work in improving and standardising the illuminants available. The enquiry he proposed would thus be supplementary to the work of this Committee, with which it would co-operate, by tracing the actual results of such improvements in practice. It was clearly essential that the data in various mines should be collected by recognised experts so as to be strictly comparable, and that there should be continuous investigations covering the conditions before improvements in lighting were made, during the period of improvement, and afterwards, so that a complete record might be available, and decisive conclusions drawn. He hoped that the Home Office would lend its sympathetic support to this investigation.

The CHAIRMAN (Mr. J. HERBERT PARSONS) said that he had very little doubt that the difficulty in regard to the incidence of miners' nystagmus was due to the low illumination. He thought that the figures presented by Dr. Llewellyn and others were conclusive on this point. The remedy consisted in providing a higher order of illumination, by the use of lamps of greater candlepower, possibly aided by special reflecting devices. From the scientific standpoint it was a difficult matter to devise an electric lamp which would give an adequate indication of the presence of firedamp, and he was not certain that this problem had yet been solved.

In view of the large number of speakers the time available for each had been unavoidable limited, and he hoped that those taking part in the discussion would send in their remarks in a fuller form for publication in the official organ, and that others who had not been able to be present would also send in written contributions. The discussion would furnish a useful review of the position and would serve as a basis for further investigations on the lines suggested by Mr. Cridland and Mr. Gaster.

Sir GEORGE A. BERRY, Edinburgh (*communicated*):—

I must congratulate the Society on the energy and enterprise shown in promoting such a meeting, and I greatly regret that I cannot possibly arrange to be present. I entirely agree with Dr. Llewellyn's conclusion that the most important factor to be considered in the etiology of miners' nystagmus is that of illumination. It is certainly desirable, on economic as well as humanitarian grounds, to settle as far as possible the question of the amount and character of illumination.

I do not find myself in such complete agreement with Dr. Elworthy with regard to the type of nystagmus which he refers to as incurable. I doubt if any etiological influence can be ascribed to the action of ultra-violet rays. The symptoms, as I know them, are more consistent with, and probably due, to the same causes as those of other more familiar types of asthenopia. But this is a minor point.

As regards the etiology too, of miners' nystagmus in general, there are other factors besides that of defective illumination. One important one is the constrained position of the eyes required in fixation. But the effect of this factor is so much aggravated by, and so dependent upon, defective illumination, that it is practically eliminated when the illumination is made sufficient. While, therefore, of scientific interest it does not enter as a factor of primary practical importance.

There are other more general factors connected with ventilation, a dust-laden atmosphere and general health which, though important in a way, are all more or less subsidiary.

In fact there can be no doubt that the first, and main, question to be settled is that of safe, efficient illumination. I

hope your Society will solve this point and that the discussion will lead to far-reaching practical results.

Sir JOSIAH COURT, Staveley (*communicated*):—In dealing with miner's nystagmus it must be borne in mind that coal miners are a selected class of workers, because only men of strong physique can work down a colliery.

Compared with other men, they are well fed and clothed, and their children are hardy and strong. A large proportion of them start work in the pits as boys, and if found after a time to be unfit they leave the colliery for other jobs.

Thousands of miners have oscillations of the eyes when at work, and they are not aware of it. In the daylight the eye movements are hardly to be detected.

When I examined 106 miners down two collieries near Staveley in the year 1912, forty-one "holers" were tested, twenty of them had nystagmus, but not one of them was incapacitated from work.

When I questioned each man before my examination, he said that he had nothing the matter with his eyes.

Bad cases of nystagmus, with giddiness, headache, night blindness, photophobia, blinking of the eyelids, etc., no doubt have inherited a nervous predisposition to the disease.

I saw two young men down the pit in 1912; they were brothers, aged 32 and 43. Both had nystagmus in a bad form. Neither of these young men had ever been off work on account of their eyes, and they made no complaint of them to me.

Now comes the practical question: What kind of lamp and light is best suited for the relief of those cases of nystagmus?

In my opinion it is a *sine qua non* that a miner's lamp should give a good illumination, and that the light must be diffused equally in every direction so that a miner can see clearly all round as well as in front.

Again, men with nystagmus complain of the glare from the white light of the electric light. It would very much relieve these sufferers if amber-coloured glass, or Crookes' glass, was used to cover the bulb of the electric lamp. The ultra-violet rays which cause the irritation would then be cut off.

Last January I went down one of the Staveley Collieries and tried an electric lamp with glass cover stained light amber. The miners found it very comfortable to work with. The glare was completely removed.

I notice that some authorities advocate the use of an electric headlamp, with tube and battery, the latter carried on the back with a belt round the waist.

The only one I have seen has a light the radius of which is too small and the light too concentrated. It does away with the lateral vision, also it does not illuminate in every direction. A miner in a stall cannot see all round him unless constantly moving his head. Again, the headlamp and the cap with tube and battery must clog the movements of the body and in hot pits, where the temperature at the coal face is over 80° and the men work stripped to the skin, the apparatus would increase sweating and fatigue, and become intolerable. Moreover, the long tube and battery would prevent a man from heaving up a tub with his back against it.

After all, an electric lamp without shadows, which can be put on the ground with nothing to prevent the diffusion of light everywhere, is the best for the coal-getter.

There may be trouble with the batteries, but in time all difficulties should be overcome.

Dr. GEORGE MACKAY, Edinburgh (*communicated*):—

I have examined the papers presented by Drs. Llewellyn and Elworthy, and am in general agreement with the opinions expressed by both writers. There is no question that the great desideratum is a lamp for the use of miners giving more efficient illumination, sufficiently strong to stand rough usage, and cheap enough to commend itself to the mine owners.

Mr. STANLEY NETTLETON, Lecturer in Mining at the Royal School of Mines (*communicated*):—

As a mining engineer whose experience has been largely in coal mines, I have come in touch with cases of nystagmus, and though this disease is undoubtedly associated with defective illumination

underground, I very much doubt if improved lighting in the mines would bring about beneficial results to the extent suggested by some of the speakers in the discussion.

Statistics regarding accidents and output are apt to be misleading unless they refer to a field of considerable extent. I should be glad if Dr. Llewellyn would state the number of men employed at pits A and B, referred to in Table 5 in his paper. Do the figures for output per person per shift imply that at pit B the men did 5 per cent. more work than at A, where oil lamps were used? How are these figures obtained as it is not stated whether the units quoted refer to lbs. or trucks of coal? Further, were the conditions of working the thickness of coal, character of roof, etc., in the two pits A and B practically the same in each case?

In the discussion of the paper one speaker referred to five cases of nystagmus in a mine employing 2,911 men. It is obvious that the reporting or failure to report the disease in a couple of instances would make considerable difference in statistics which merely quoted on a percentage basis.

I have no interest in any particular type of lamp, and while I believe that a better light might tend to reduce nystagmus and possible also accidents from falls of roof or side, etc., in working places, the fact must not be overlooked that in comparing an electric with a flame lamp the latter is not to be regarded only as a source of light but also as an indicator of the presence of firedamp and of foul air. Apparently no electric lamp has yet been devised to perform these two functions.

Mr. A. P. WELCH (*communicated*) :—

I should like to thank both lecturers for the interesting details put forward, and the conclusion I think that everyone must draw from their remarks is that the electric safety lamp undoubtedly is greatly superior to the flame lamp for colliery use.

Personally, I have no hestitation in saying that the electric cap lamp is the lamp of the future. Its extensive use in the United States of America has proved it a most satisfactory source of light, and I concur entirely with Dr. Llewellyn's remarks concerning it. I would like to ask if Dr. Llewellyn has any figures he can give us showing the prevalence or absence of miners' nystagmus in American pits where this cap lamp is used.

I was interested particularly in the remarks made with reference to the whitewashing of portions of the workings. About 18 months ago I wrote a short article on miners' nystagmus which appeared in *Electricity* (August 23rd, 1918). In this article I suggested that sheets of three-ply wood should be sprayed with whitewash and used in the workings in suitable positions, so providing a comparatively large reflecting surface. Such a method would be quite cheap; the whitewashed boards can be arranged to the best advantage, and would reflect a very large proportion of the light falling upon them, their reflecting surface can be kept in good order by spraying with whitewash at suitable intervals. In view of the question of modifying the colour of the light, it may be advantageous to spray the boards with some colour wash which can be modified to suit the chromophotic index as suggested by Dr. Elworthy.

The half-watt lamp is in my opinion not the solution of the problem. My reasons for this statement are as follows:

The filament length of a standard 2-volt. bulb is small, and the cooling effect of the leading-in wires very considerable; in consequence, the actual portion of the filament giving the largest amount of useful light is probably at, or near, half-watt efficiency, and it is doubtful if much improvement can be made in this direction on a 2-volt. bulb.

When these small bulbs burn out it will be found that the break nearly always occurs at the middle of the filament.

I am quite certain that the solution of the problem will be found by using :—

(1) A cap lamp.
(2) A 4-volt. battery.

My reasons for this assertion are as follows :—

(1) In the cap lamp the light can be concentrated in the required position, and a very much more efficient reflector can be used

(2) With the cap lamp, the lamp is much closer to the coal face and less liable to damage than the type of safety lamp at present in use.

(3) The general working efficiency of a 4-volt. lamp is higher than that of a 2-volt. lamp for the reason given above.

One of the speakers suggested that miners' nystagmus might be caused by some micro organism, but I believe that many experiments have proved that freshly cut coal is entirely germ free. It is possible, however, that spores of some yet unknown germ do exist, and will one day be isolated. This has already occurred, although perhaps it is not quite a parallel case, with a disease at one time so prevalent in the German coalfields, and which gave considerable trouble in our own Cornish tin mines, which disease was afterwards found to be due to the Ankilostoma worm.

With reference to the lamp suggested by Dr. Llewellyn, a drawing of which he shewed us; I think most safety lamp manufacturers will agree that the type of reflector there suggested is of comparatively little use in safety lamps, the bottom reflector does not catch much light as the lamp bulb cap shields it very considerably; also the top reflector is cut down as much as possible in order to reduce the overall height of the lamp. My own experiments have shown that reflectors of this type are of very little use.

Mr. C. S. PERCIVAL, Newcastle-on-Tyne (*communicated*):—

I have been trying to get a thoroughly satisfactory view about the cause of coal-miners' nystagmus, and have so far quite failed.

The deficiency of light has *prima facie* much to recommend it, but there are some serious objections to it:—

(1) Nystagmus does occur in other occupations, though rarely, when full illumination is present, e.g., ceiling paperers (I think Snell drew attention to this first). I published a case of acquired nystagmus in a railway clerk whose business was to run his eyes along very long columns or rows of figures in a huge folio all day. He had the tremors and other symptoms of coal-miners' nystagmus. The illumination was quite good. To-day, at the Eye Infirmary, I saw a young man of only 20 who had the classical rotatory nystagmus, who had been engaged in the same pit with safety lamp illumination since the age of 14. Yet he said the nystagmus had only come on in the last two months, and attributed it to his working in the last three or four months in an especially narrow seam (two feet). So this case, as far as it goes, supports Snell's view of strained position, especially looking obliquely upwards and to one side. This was the position in which he said he had to keep his eyes, and to this he attributed the condition.

In the pits about this district the miners themselves attribute the nystagmus to several causes.

With about equal frequency to strained position of eyes and to deficient illumination; four years ago the strained position was far the most frequently alleged cause. In some gassy pits it is regarded as due to the toxic effect of the gas; but it may be noted that in all gassy pits safety lamps are used. Latterly I have had several men who have been convinced that it was due to the gases given off the explosives used—saxonite, etc. Altogether it is a most perplexing subject, and my own impression is that the cause is not yet known.

The following is a most important point. It is well-known that one of the early symptoms of the disease is an inability to see the blue cap, unless it is very large, which appears over the flame of the safety lamp in the presence of gas (firedamp). In the pits in this neighbourhood it is the custom for "viewers" to traverse all the mine passages before each shift with a safety lamp, in order to see that the pit is safe. A rough idea of the percentage of gas present in the air can be made from the size of the blue cap. Now I have personally been consulted by two viewers who both had miners' nystagmus, and yet they were still engaged in this most important and responsible work. I would urge most strongly that every viewer should be tested every six months as to his ability to detect the blue cap. The test can be quite easily and quickly made. A gas cupboard with a glass window in front containing one or two safety lamps. Ordinary coal gas can be admitted into the cupboard to the

partition holding one of the lamps. The blue cap will appear and will increase in size according to the percentage of coal gas present.

If the miners were told of the extreme importance of this test, and were shown that the safety of their lives depended upon it, I think that there would be no hesitation in its being accepted by the Miners' Federation. If it were not accepted of course there might be miners' strikes in sympathy with a "viewer" who lost his appointment owing to his getting coalminers' nystagmus.

I have no doubt that many of the explosions in mines have occurred due to this cause, that the viewer for the district in the coal mine, where the explosion occurred, was affected with this disease.

Of course electric light would be very desirable in a pit, but at the same time I think that it would be well to have a safety lamp also placed every 30 yards or so near the workings. Every pitman should be warned to look now and again at the safety lamp to see if there was a blue cap over its flame. In this way warning would be given if there were a sudden escape of gas from the workings.

Experiments are needed in order to ascertain the best form of light. A 16 or 32 candlepower electric lamp of fair size is more agreeable to the eye than one in which the same candlepower is concentrated over a filament of smaller area and higher specific luminosity. The ideal source would be one in which the light is completely diffused, in somewhat the same manner as in the mercury lamp.

Dr. J. A. Wilson, O.B.E., Glasgow, (*communicated*):—As I had to leave the meeting at an early hour, I am pleased to comply with your request for a short summary of the remarks I proposed offering.

I have always maintained that the nystagmus of miners should not be regarded as being an entity in itself. The so-called "miners' nystagmus" forms but a small percentage of the total number of cases of nystagmus that exists in the general population. Now all these cases are alike in their manifestations; all are one and the same disorder.

If we are to argue from conditions and symptoms back to the cause of the disorder, then we should do so, not in a sectional, but in a comprehensive manner.

During the last two months I have seen four cases of nystagmus. These patients were all girls; three of them had fair hair, all had defective vision from causes other than the nystagmus and one had the peculiar backward tilt of the head with the serious facial expression so frequently seen in the coal miner. One was a very interesting case of latent nystagmus. She squinted with one eye and the vision in this eye was defective. The vision in the other eye was good. When first seen she had no obvious nystagmus. I covered the good eye with a card and immediately nystagmus ensued. What happened when I covered the good eye? Plenty of light was entering the squinting eye, and some light from behind the card was also entering the good eye. It was not the want of light that produced the nystagmus, but the light that entered the good eye was unable to focus and form retinal images.

The albino is peculiarly liable to nystagmus and here there is too much light in the eyeballs, but well-defined images are not formed. Nystagmus is liable to occur where there is error of refraction, squint, eye defect, blindness, or conditions approximating blindness, such as in the dull illumination of the coal mine.

The one feature that is common to all cases of nystagmus is the imperfection, or the absence, of retinal images.

Can anything to done to give better retinal images to the man working in the coal mine? The dull black of the coal face does not provide them. Mr. Elworthy's suggestion to introduce patches of white may help in some measure to provide distinct retinal images. Splashes of whitewash seem desirable; perhaps even the coal face could be occasionally splashed or have some white powder thrown over it.

I am not qualified to say anything on lighting, but would suggest that it should be diffused and not reflected.

[Contributions—"Nystagmus," *British Medical Journal*, Nov. 1st, 1913; "Nystagmus," *The Lancet*, Oct. 23, 1915.]

Dr. LESLIE BUCHANAN, Surgeon to the Glasgow Eye Infirmary (*communicated*) *:*

Having seen many cases of this interesting condition and carefully interrogated the men who were the subject of it, I have come to be a firm adherent of the belief that the primary cause is *defective illumination.*

In nearly all cases the men work with a safety lamp of some kind. Exceptions to this rule are quite uncommon.

It may be the case that another factor is a determining cause, namely, *instinctive protective action,* which causes the eye to turn upwards in an oblique direction.

So far as my investigations go there is no very definite hereditary tendency to nystagmus, but miners frequently have sons who work in the same pit as they do and, under similar conditions, develop nystagmus whilst the parent also suffers from it.

I have been unable to find any support for the view that miners' nystagmus is caused by a congenital cerebral defect which results in muscular instability.

Regarding treatment there is no doubt that the only satisfactory method is immediate cessation of work underground in any capacity. It is advisable for the man to do no work of any kind for some weeks, but go out of doors as much as it is feasible.

The prevention of the condition mainly depends upon the possibility of obtaining good illumination, and a miner who has suffered from nystagmus, being liable to recurrence if subjected to similar conditions as regards lighting, etc., would be well advised to change to another colliery where conditions were less liable to call out this particular symptom.

Mr. H. F. JOEL (*communicated*):—In view of the inevitable limitation of time available for the discussion of this interesting paper, I gladly avail myself of the Chairman's invitation to contribute some supplementary remarks. I observe that Dr. Elworthy refers to the desirability of colour relief amidst the dark surroundings prevailing in mines. In the "Joel-Fors" lamp, which I had the pleasure of exhibiting at the meeting, the bulb of the lamp had been stained with a yellow preparation, occasioning a diminution in intensity of light of from 2 to 1·5 candlepower, but having, he believed, advantages which more than compensated for this loss of light. The difference in quality of the light was illustrated by the manner in which the brass pillars of the lamp showed up in their true colour. I should very much like to hear Dr. Elworthy's opinion of the value of the principle adopted. I have already found that in some cases the yellow tinted lamp is preferred to the clear bulb, which can, of course, be equally well used in this lamp.

I trust that the suggestion of a joint committee to discuss the whole question of lighting in mines and its effect on eyesight will be carried into effect. As the subject would naturally require prolonged investigation, and as new factors are continually being introduced, such a committee ought to be of a permanent character. There are also other questions relating to the use of electric lamps in mines which ought to be authoritatively settled, for the assistance of lamp-makers and the guidance of users. Amongst these are the purity of the acid and also of the water used in filling cells, and the conditions of charging (especially the limitation of the charging voltage, which has in some cases been responsible for fires). Such matters as these ought also to fall within the scope of an advisory committee on mine-lighting whose recommendations would carry weight; at present makers of electric lamps find it difficult to secure that good practice is adhered to, with consequent prejudice to the life of batteries, and to the available light during a shift. It is important also that the electric lamps should be placed in a separate lamp cabin, or room, and not in the same room as the oil lamps.

I have made forms of lamps, both with the ordinary cylindrical chimney, allowing light to pass in all directions, and inspection-lamps, in which the light is mainly concentrated over a smaller area, by means of special reflector and lens. The latter form commends itself to inspectors, but I have found that, in spite of the much higher local illumination available, miners prefer the lamp giving general lighting. In this and other matters it is only right to be guided largely by the actual experience of the miner in his work.

THE INFLUENCE OF CONDITIONS OF ILLUMINATION UPON THE EYESIGHT OF WORKERS IN COAL AND METALLIFEROUS MINES.

Contribution from Dr. M. STASSEN of Liège.

WE have received from Dr. M. Stassen, who has had exceptional experience of the conditions in mines in the areas in the vicinity of Liège (Belgium)—both coal and metalliferous—some very full and comprehensive data on miners' nystagmus, which form a most valuable supplement to the paper by Dr. Llewellyn.

Dr. M. Stassen has dealt with the whole subject very completely in his book,* and has also sent us a more recent contribution which appeared in the *Bulletin of the Société Belge d'Ophthalmologie.*

While it is impossible to do more than give a very brief summary of these comprehensive data, we propose first to give some idea of the data bearing on illumination and eyesight in Dr. Stassen's book, and then to refer to this supplementary communication.

In his work on "La Fatigue de l'Appareil visuel chez les Ouvriers Mineurs," Dr. Stassen gives the results of investigations on 14,000 workers, including 7,925 who were examined when descending and ascending from the mine, *i.e.*, before and after work. A fact of special interest is the recognition of typical cases of nystagmus amongst workers in iron and zinc mines who have never worked in coal mines, thus disposing of the suggestion that nystagmus is necessarily connected only with the working of coal. The very large number of factors affecting vision are discussed (such as age, influence of heredity, period of employment, nature of work, dimensions of galleries, etc.) and a distinction is drawn between cases in which defective illumination was judged to be practically the sole cause of nystagmus, and cases in which the special nature of the work, occasioning abnormal elevation of the eyes, or otherwise causing visual fatigue, was also a contributory factor.

In the case of 182 workers examined in zinc mines nine showed oscillatory movements of the eyes, and these were men who for several years had used oil lamps and candles. On the other hand, those workers who had always used acetylene lamps showed no sign of these effects. In connection with coal mines an interesting fact recorded is that the cases of nystagmus were at least twice as numerous in men who went underground for the day-shift as compared with those who entered the mines at night. Statistics relating to mines using respectively candles and oil lamps and electric lamps showed that where the illumination had been improved the percentage of cases of nystagmus was materially less, and that where efficient portable electric lamps had been introduced the affection had become less serious, although it had not yet disappeared. The conclusion is drawn from a very large number of data :—

"Inadequate lighting in mines can thus, by itself, give rise to 'jerkiness' of vision (*secousses oculaires*). Workers operating by inadequate illumination from safety lamps show a notable proportion (more than 10 per cent) of cases of nystagmus, whereas workers in the same category, receiving light for more than one year from incandescent electric lamps (32 candlepower) show no signs of such jerkiness of movement of the eyes." (This relates to cases in which defective illumination was considered to be the sole cause responsible for nystagmus.) Another group of observations relates to cases where the nature of the work imposes special strain on the elevating muscles of the eye, but even here, when the conditions of illumination are satisfactory (*e.g.*, acetylene lamps with reflectors fixed, incandescent lamps on electric supply, etc.), cases of nystagmus are not met.

* "La Fatique de l'Appareil chez les Ouvriers Mineurs," by Dr. M. Stassen (Liège, 1914–1919).

A description is given of some of the chief forms of miners' lamps, and the following instructive conclusions are drawn :—

"An improvement in conditions of illumination exercises a favourable influence on the frequency and evolution of nystagmus in miners. All visual troubles amongst miners diminish more and more in proportion to the improvement in conditions of illumination at the bottom of the mine.

Thus :—

(1) The number of grave cases of nystagmus, complicated by general nervous trouble, may be estimated at :—

35 per 10,000 workers making use of safety oil lamps (lampes de sûreté à l'huile grasse).

12 per 10,000 amongst workers operating for three years by safety benzine lamps.

8 per 10,000 amongst workers operating for two years by portable electric lamps.

0 amongst workers making use of candles of naked flame lamps.

(2) The number of cases of pronounced nystagmus (visual oscillations horizontally or a few degrees below the horizontal) is :—

57 per 1,000 workers using oil lamps.

44 per 1,000 using benzine lamps for three years.

13 per 1,000 workers making continuous use of candles or lamps with naked flames.

12 per 1,000 workers making use, for two years, of portable electric lamps.

0 per 1,000 workers making use for two years of acetylene lamps with reflectors.

(3) As regards day-shift workers, in the various coal mines visited we have noted :—

31 per cent. of cases of nystagmus amongst workers using safety oil lamps.

21 per cent. amongst workers who have used benzine lamps for about two years.

15·4 per cent. amongst workers who have used electric lamps for about two years

0 per cent. of cases of nystagmus amongst various types of workers whose employments were such as to enable incandescent electric lamps of 32 and 64 candlepower to be used.

Thanks to the use of acetylene lamps with reflectors, the disappearance of nystagmus is an accomplished fact in metalliferous mines.

In his supplementary communication to the *Société Belge d'Ophthalmologie* Dr. Stassen recalls the discovery of cases of nystagmus in the iron and zinc mines mentioned above, and remarks that these mines were formerly lighted by naked flame oil lamps, the conditions being thus similar to those formerly existing in "safe" coal mines. Unfortunately, the fact that acetylene and electric lamps have been generally introduced into such mines makes it difficult to trace the prevalence of nystagmus in such mines under the old conditions. However, in an iron mine in the Sol district, where acetylene lamps have been in use for only two years, three cases of fairly pronounced nystagmus were rediscovered. One of these subjects described his symptoms during the period when he worked by candles. He found great difficulty in finding his way in the evening on leaving his house; bright lights, when suddenly exhibited, appeared to dance before his eyes. When acetylene lamps were introduced, he accordingly found some difficulty in getting used to the new and brighter light, and at first he could actually see less well by its aid than by candles. But this period of transition passed, the sensation of glare diminished, and the tendency to visual oscillations grew less. The condition of his eyes improved generally, until to-day the only trouble he finds is a momentary sensation of dazzle when leaving the cage after ascending the mine and coming to bright sunlight. This case is emphasised as completely bearing out the conclusion that prolonged work in badly lighted galleries is in itself sufficient explanation of nystagmus. Further investigations in iron and zinc mines have shown that no cases of nystagmus have been met where workers have always used acetylene lamps; on the other hand, cases are

Type of lamp	Candle-power (Hefner)*	Candle-power at end of period of work	Constancy of Lamp	Colour of Light	Glass due to exposure of lamp to eye	Number of grave cases of Nystagmus per 10,000 workers	Number of serious cases of Nystagmus per 1,000 workers	Number of cases of Nystagmus per 100 workers on day-shift	Are there cases of Nystagmus amongst workers who, in the course of their vocation, have used only one form of illuminant, to the exclusion of others ?
Safety oil Lamp	0·5	0·28	Wavering flame influenced by currents of air and by humidity	Yellow tinged reddish	Considerable, especially at the end of the shift	35	57	31	Very numerous amongst workers who have only used safety oil lamps
Safety benzine lamp	1·01	0·8	Flame sufficiently steady, but influenced by currents of air	Yellowish	,,	12	44	21	Less numerous amongst workers who have only used safety benzine lamps
Candles and naked flame lamps	0·7	0·7	Flame much influenced by current of air and by humidity	Yellowish	Appreciable (if worker does not carry candle above his cap)	0	13	28	Cases are known amongst workers who have only used candles
Portable electric safety lamps	1·75–2	15–1·75	Rigid	White	Appreciable but less marked than in other illuminants	8	12	15·4	We have not met any cases of Nystagmus amongst miners who have only used electric lamps, but the inquiry has at present extended over an insufficient number of years, and is to be continued
Acetylene lamps	8-15	8–15	Fairly rigid, and little influenced	White, and agreeable to the eye	None, owing to use of reflector	0	0	0	We have met no cases of Nystagmus amongst miners, who have worked only by the light of acetylene lamps

* 1 International candle = 1·11 Hefner candles.

rediscovered amongst those, the older workers, who formerly worked for a long time by candles, although the affection was relatively slight when acetylene lamps had since been used for a relatively long period. Thus, workers who had formerly contracted pronounced nystagmus in coal mines found that their affection diminished, and ultimately disappeared after they had been engaged for several years (the statistics cover a period of six years) in metalliferous or phosphate mines where acetylene lighting is in use.

In works in which acetylene lamps have been in use for ten years, and in areas where work has proceeded for at least three years by fixed electric lamps of 32 and 64 candlepower, no new cases of miners' nystagmus have been observed.

The author concludes by remarking: "We are persuaded that miners' nystagmus is simply merely a symptom of nervous affection, arising from the visual fatigue imposed by working under conditions of inadequate illumination."

The accompanying table (p. 105), summarising the characteristics of the chief available miners' lamps, together with data regarding the prevalence of nystagmus, is appended.

Dr. T. Lister Llewellyn, in reply: I must congratulate the Society on the very full discussion and hope that the practical outcome will be the formation of the committee which Mr. Cridland and Mr. Gaster advocate. Mr. Elworthy rightly draws our attention to the quality as well as the quantity of the light required. Since the meeting, I have repeated some of his experiments, and am in general accord with his results: that the electric lamp gives out twice the amount of blue rays as a candle or oil flame, and that the blue rays alone produce discomfort and fatigue of the eyes. I do not quite agree with his deductions. In practice the blue rays are never met with alone, and I do not think his "incurable cases" are the result of ultra violet burns. His own figures show a great improvement in the incidence of nystagmus since the introduction of electric lamps. It is true that he lays great stress on the improvement of ventilation, but on this point the statement of Dr. Haldane, who has paid so much attention to this subject, must carry more weight.

To take his own figures; in the first table the average surface brightness of the three pits given is 0·0005. Assume that 10 per cent. blue rays are reflected, this would be 0·00005. Which would seem the more likely to cause disease, the positive effect of blue rays of this power, or the negative effect of working in such a feeble illumination as 0·0005 foot-candle? It is undoubtedly much easier to look at a candle-flame than at an electric lamp of the same candle-power. This is due to the greater luminosity of the wire loop compared with the candle-flame of the same total luminosity spread over an area a thousand times as great. If you throw the light from a standard candle and electric lamp of 1 candlepower on a white surface, screening both lights, all sense of discomfort is lost. If you can only get a diffused light or prevent the light from falling directly into the eyes, the electric light is as comfortable to work with as a candle. It is possible or even probable, and the remarks of Miss Sayer and the exhibition of the Joel-Fors lamp bear this out, that the introduction of a suitable light filter would be beneficial.

Dr. Haldane will be interested to hear that his suggestions for the pathology of the disease are those put forward so ably by Dr. Stassen who speaks of the "Fatigue of the Visual Apparatus of Miners." Dr. Stassen's book is well worth perusal, and the table I have extracted from his book shows the importance he attaches to the influence of light. On p. 166 he says he has arrived at the conviction "que la cause necessaire et suffisante des troubles visuels des ouvriers est le travail prolonge dans de mauvaises conditions d'éclairage." He has also suggested the use of uranium yellow glass, and says that some of the men place paper between the bulb and glass of their lamp.

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Mr. Armitage's figures are very interesting, and also his remarks about the saving of time while getting away from the pit bottom. This is especially true when the main roads have been whitewashed. This point has also been referred to by Mr. Fudge, and measurements I have taken lately show that the light reflected from a road which has been stone dusted is two to three times that reflected from an untreated road near the coal face.

It is only too true, as Mr. Hailwood points out, that the statistics of miners' nystagmus are not always consistent, but great care is required in shifting the evidence obtained. The increase in the number of cases from 1907, which was the first year when compensation was paid, is largely due to the increased knowledge of the disease. The loss of coal output is real, and although the number of men now employed is greater than before the war, owing to the shorter hours, the nett result is a shortage of men painfully obvious when the coal output of the country is compared with pre-war years. The men lost are the skilled men, and the coal getter is a highly-trained workman, who cannot be replaced by any Tom, Dick or Harry the manager is able to lay his hands on. With regard to the safety of the cap lamp, it is quite true to say that the lamp is not absolutely safe—but what lamp is ? Certainly not the oil lamp which is vulnerable in all directions. The cap lamp is only a two-volt lamp, and the probability of ignition of gas from breaking of the cable is very remote.

One of the points which Mr. Hailwood makes is that the miner does not give his lamp the attention it requires. This is quite true, and combustion lamps especially require much care and attention which the collier will not give. Surely this is one of the best arguments for the introduction of the electric lamp. The glass difficulty to which the speaker also refers is a very serious one, applying both to the oil and electric lamp manufacturers.

Mr. D. L. Davies says that defective lighting has never produced nystagmus in other conditions than coal mining. Seamstresses working on urgent mourning orders have developed temporary nystagmus. Dr. Collie (quoted in Thompson's " Diseases of Occupation ") found 28 per cent. of 516 female sewing machinists suffering from slight nystagmus. Stassen has found nystagmus in zinc workers. I cannot accept his theory of chronic poisoning—the air in mines is remarkably pure, and its chemical composition has been worked out fully by Dr. Haldane and other observers.

The strain and stress of modern warfare, as Pooley and Harford point out, converted many latent cases of nystagmus into the manifest disease. I saw several cases in France in 1915-17. My figures with regard to the seasonal prevalence of

the disease are based on the total number of cases only, but as almost all my cases come from steam coal pits, the remarks of Mr. Cridland about the short working period of the house coal pits in summer do not apply. It may interest Mr. Cridland to have my results up to the end of March, 1920. First quarter 353, second 226, third 222, and fourth quarter 314. "Safety" acetylene lamps have been tried, but were found so dangerous that their use has been forbidden. Sir Josiah Court, who must be pleased at the general acceptance of his views, must have used a cap lamp with a bull's eye lens. If a plain bevel glass is used the area of illumination is very large.

Mr. Welch asks me for the incidence of nystagmus in America. I cannot give any figures, but the disease is very uncommon, and there is no American literature on the subject except an able review by Hoffman (Bull No. 93, Bureau of Mines, U.S.A.). Mr. Welch's suggestion of using white-washed screens is well worth a trial.

Mr. Nettleton asks for the number of men working in pits: A and B, table V. pit A, 600 men; pit B, 200 men. The conditions of work were exactly similar, the same seam was being worked, and the pits were only a mile or two apart. The output in tons by the colliers in B was 5 per cent. greater per man than in A. I stated at the meeting that the numbers were too small to draw permanent conclusions. The test had, however, been going on for five years.

To summarise—while there is a consensus of opinion that miners' nystagmus is due to deficient light, some observers hold that there are other important and possibly unknown factors at work. There is, however, no difference of opinion in the view that the lighting conditions of the coal mine need improvement. The standard I suggest as a minimum is that of the open light pit, which is about five times as great as that obtaining in the safety light pit. To obtain similar illumination you must either introduce a safety lamp of 3 to 4 candlepower or bring the light nearer the working area by the use of a cap lamp. Many speakers think a cap lamp will be unpleasant to work with and impracticable, but there are over 200,000 of these lamps in use in America and giving satisfaction. I think it will be found much safer than the oil lamp, and its advantages from the point of view of illumination are incontrovertible. It may be that the use of a light filter will help in the prevention of eyestrain. The more extended use of whitewashing and stonedusting will almost solve the problem in the road-ways.

THE GLASGOW LIGHTING ASSOCIATION.

READERS will be interested to hear of the formation of the Glasgow Lighting Association, under the Honorary Presidency of Mr. S. B. Langlands, Public Lighting Inspector to the City of Glasgow, who is also a member of the Illuminating Engineering Society. The Acting-President is Mr. J. F. Colquhoun, and the Secretary Mr. J. Ward (20, Trongate, Glasgow). We have received a copy of the syllabus of papers for 1920, which includes papers on "Photometry" by Mr. E. Stewart, on "Illuminating Engineering Glassware" by Mr. J. Mitchell, and on "Incandescent Gas Mantle Manufacture" by Mr. W. Scott. Other items of interest include a visit to the generating station of the Electricity Department of the City and to various works in the vicinity. There are also papers on "Brass Castings," "Electricity," "Electric Wiring on Stairs," etc., and we note that the presidential address will be delivered on December 15th.

Members of the Illuminating Engineering Society will join us in wishing success to this new body in disseminating the principles with which this Society is identified.

4

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

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EDITORIAL.

Motor-car Headlights in relation to Traffic Requirements.

The design and use of motor-car headlights has been discussed on various occasions before the Illuminating Engineering Society, notably in the paper contributed by Dr. H. R. B. Hickman in 1911. In July, 1909, a series of tests was carried out by the Royal Automobile Club, while in 1912 and 1913 experiments were conducted by the National Physical Laboratory at the request of the Local Government Board. In this country the matter was still under consideration at the outbreak of war, but during the ensuing five years conditions were naturally abnormal, special regulations prescribing the dimming of headlights and the diminution of public lighting being introduced for military reasons. It is only now that we are free to consider the question again in its normal aspect.

The discussion before the Illuminating Engineering Society on March 30th was therefore timely, especially in view of the recent issue of the interim report of the Committee now sitting under the Ministry of Transport. Our thanks are due to Mr. J. W. T. Walsh for opening this discussion at somewhat short notice. His introductory paper, which is presented in this issue (pp. 114-118), contains a useful survey of the situation, and is concluded by a series of questions which provide an excellent starting-place for further investigations. The experience of the United States, which was free from the abnormal circumstances arising from visits of hostile aircraft during the war, is interesting at the present moment. Progress in that country is briefly summarised by Mr. Walsh, and Dr. C. H. Sharp has also favoured us

with a copy of a recent paper by himself and Mr. Little, which brings the available information up to date.

The solution of the problem involves a compromise between several distinct and generally conflicting factors. On the one hand we have the requirement of the driver, who needs a powerful beam of light to enable him to perceive approaching persons, vehicles, or obstacles on the road; on the other hand, we have the experience of the driver or pedestrian facing an approaching motor-vehicle whose eyes are apt to be dazzled by glare from the approaching headlight. Opinion seems to have fluctuated between these two elements. At the time of the tests at the Crystal Palace attempts were being made to increase the power of the beam; subsequent progress in the design of lamps and reflectors, however, has enabled considerably higher beam-candlepowers to be developed. Accordingly recent attempts to frame regulations, especially in the United States, seemed to be concerned chiefly with the avoidance of excessive glare. The inquiry conducted by the Illuminating Engineering Society in the United States was a scientific attempt to reconcile the claims of drivers and pedestrians and its conclusions were adopted by various States. It is hoped that eventually regulations suitable for uniform adoption throughout the United States will be reached.

From the evidence available we find a general recognition of the need for a minimum beam-candlepower (variously fixed at 1,200—4,800 candles) in order to enable the driver to recognise a substantial object on the roadway in time to pull up his car. It is also agreed (although it may be difficult to define this requirement by regulations) that the majority of the light should be concentrated below the level of the eyes of both drivers and pedestrians—say $3\frac{1}{2}$ or 4 ft. above the level of the roadway. There are other factors, such as the provision of a sufficient, though diffused, light at the side of the car, which should be embodied in the ideal headlight. As appears from Captain Stroud's contribution to the discussion, headlights have been designed which meet these conditions with considerable success, and in these cases the liability to glare is doubtless materially diminished.

Experience already available thus offers a useful guide to designers of headlights, but the framing of regulations expressing these requirements requires care, and they should enable the large number of headlights at present being used by motorists in this country to be readily converted, so as to do what is needed. It is naturally difficult, even for a trained observer, to decide by looking at a passing car whether its lights comply with regulations, and it might be easier to specify certain laboratory tests to be complied with by the lights of any driver desiring a licence. Appeal could be made to accredited laboratories for a verification test in any suspected case.

We should like to emphasise strongly the desirability of uniformity of action throughout the country. We are glad to observe that the committee sitting under the Ministry of Transport has the matter in hand. The framing of suitable regulations cannot be settled merely by interchange of opinion. Exhaustive tests, with different types of headlights, must be made under official supervision under varied conditions of traffic and climatic circumstances, and the results recorded and analysed by experts. The Committee naturally desire to be fully informed before taking action, and we need hardly say that the Illuminating Engineering Society will be glad to be of any further assistance in connection with their inquiries and experiments.

Street Lighting and Motor Traffic.

Whatever means be adopted for securing the requisite beam-candle-power and diminishing possible glare, both factors are much influenced by the nature of the street lighting provided. In a well-lighted street the contrast between a headlight and the brightness of surrounding objects is much less than in a dark country lane ; and at the same time the need for a powerful beam is also less, because the public lighting enables objects to be perceived with more or less ease. It may therefore be justly urged that public lighting and regulations for automobile headlights should be dealt with conjointly. It has been suggested that when entering well-lighted areas drivers should diminish the power of their headlights or even extinguish them altogether. But in order that this practice may be general there should be a more uniform standard of public lighting, according to the nature of the street, not only in London but throughout the entire country. We have often drawn attention to the inequalities in lighting in the London area, served as it is by a number of distinct authorities, each adopting its own methods for lighting streets—a condition that leads to contrasts in illumination such as greatly interfere with the safety and convenience of motor-traffic.

The London " Safety First " Council have marked their appreciation of this point by a special recommendation, that a change in the brightness of illumination, whether in passing from a side street to a main thoroughfare, from one urban district to another, or from the country to the immediate vicinity of a large town, should proceed gradually, by stages, so that the eye is not distracted by any sudden change in brightness.

The functions of public lighting are already different from what they were a few years ago. At the present day the safeguarding of fast-driven motor-traffic has become the primary function of street lighting. In addition to the observance of the principles outlined above, authorities can do a great deal to aid the safety of traffic by adopting various supplementary devices *e.g.*, the provision of adequate illuminated warning signals, indications of crowded crossings, sudden turns, etc. We record with pleasure the valuable work that the London " Safety First " Council has done in this direction, and we could wish that similar efforts were being made, on a co-ordinated plan, in all the chief cities and arterial thoroughfares in this country.

We have previously pointed out that the supervision of street lighting is a national and not a parochial matter, and we hope that this matter will likewise receive attention from the Ministry of Transport, with a view to the ultimate attainment of uniform methods in street lighting in relation to traffic conditions. In the work of the Road Board we already see a recognition that the upkeep of the main thoroughfares of the country is a national question. A portion of the funds derived from the taxation of motor-vehicles is understood to be applied to the maintenance of roads. It seems reasonable that some of this income should also be allotted to the improvement of lighting. This step, by enabling headlights to be dispensed with in well-lighted areas, would afford the motorist a compensating economy towards recouping him for his contribution in the form of taxes. We have little doubt that in this case also motorists would be prepared to bear a fair share of improvements made for their benefit.

Statistics of Industrial Lighting.

In dealing with industrial lighting we have often commented on the need for statistical information, showing by actual facts and figures its advantages in the interests of health, safety and efficiency of work. These advantages are admitted in general terms, but there are some who can only be influenced by concrete information of actual performance in practice, or alternatively by the presentation of the views of others showing that the arguments for better lighting advanced are generally accepted.

We are presenting in this number (pp. 131–133) a most interesting investigation of this nature undertaken by Mr. R. O. Eastman in fifteen States in America. The inquiry, in the main, followed the second method of procedure, *i.e.*, it attempted to elicit views as to the desirability of good industrial lighting and to ascertain, in cases where adequate illumination had not yet been introduced, the reason for this omission. The results are assembled in a convenient diagrammatic form. We find, for example, that of those interviewed 44·5 per cent. were well informed regarding industrial lighting, 36·4 per cent. vaguely informed, and 20·1 per cent. not informed. Further, that 55·4 per cent. of managers agreed that good lighting was vitally important, 31·6 per cent. considered it moderately important, and only 13 per cent. of little importance. This on the whole seems encouraging, as indicating a much higher level of appreciation of the advantages of good illumination than prevailed, say, ten years ago. There is, however, obviously room for further propaganda, especially among the 20·1 per cent. of persons uninformed regarding efficient industial lighting. This is further emphasised by an inquiry into the reasons offered for failure to provide proper lighting. Approximately 70 per cent. of these consumers professed to be satisfied with existing conditions, and thus required enlightenment as to the real nature of thoroughly efficient illumination.

The most interesting diagram, however, is that showing the nature of the appreciation of the benefits of good illumination. The most influential factor was clearly increase in production due to better lighting, which was admitted by approximately 80 per cent. of those interviewed. Next came "decrease of spoilage," accepted by 70 per cent. After this followed "prevention of accidents," "improvement in discipline," and "improvement in hygienic conditions," in the proportions of 60, 50, and 40 per cent. To our mind these figures afford evidence of a striking appreciation of the benefits of improved illumination.

While necessarily expressed in general terms the inquiry represents an enterprising effort to find out the state of public opinion in regard to industrial lighting, and the results should afford some useful hints to salesmen of lighting appliances. We commend the idea to the consideration of firms interested in lamps and lighting accessories in this country, and we should like to see similar methods applied to other branches of statistics, *e.g.*, those relating to accidents due to inadequate lighting. We may point out, however, that in this case it is vital that data should be collected on a uniform basis and that the assumptions made in drawing conclusions should be clearly understood. We hope that in future this important statistical branch of illuminating engineering will be a subject to international co-operation, so that conditions in various countries can be properly compared.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

MOTOR-CAR HEADLIGHTS AND REARLIGHTS IN RELATION TO TRAFFIC REQUIREMENTS.

(Proceedings at a meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, March 30th, 1920.)

A MEETING of the Society took place as stated above, the Chair being taken by LIEUT.-COL. F. A. CORTEZ LEIGH.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of the following applicants for membership :—

Ordinary Member :—

Mr. Wallis White .. Electrical and Mechanical Engineer, 24, Campbell Avenue, Langside, Glasgow.

Associate Members :—

Mr. E. A. Hailwood .. Managing Director of Messrs. Ackroyd and Best, Ltd., Morley, near Leeds.

Dr. H. S. Elworthy .. Surgeon, Ebbw Vale R.S.O., Mon., Wales.

The names of applicants announced at the previous meeting on February 24th were read out again and these gentlemen were formally declared members of the Society.*

The CHAIRMAN then called upon Mr. J. W. T. WALSH to read his introductory paper on **"Motor-Car Headlights and Rearlights in relation to Traffic Requirements."** In the ensuing discussion Captain E. STROUD, Mr. B. P. DUDDING, Mr. ELYARD BROWN, Major A. GARRARD, Mr. H. SALSBURY, Sir LANCELOT HARE, Mr. W. V. GIBSON, Mr. F. NEWTON, Mr. L. M. TYE, Lt.-Col. F. A. CORTEZ LEIGH, Mr. L. GASTER, Wing-Commander T. R. C. B. CAVE, Mr. A. CUNNINGTON, Mr. A. E. PARNACOTT, Mr. H. H. THOMPSON, Mr. C. H. WORSNOP, and Mr. A. W. WYATT took part.

Mr. WALSH, having briefly replied to some of the points raised in the discussion, a vote of thanks to the Author and to those who had exhibited apparatus at the meeting concluded the proceedings.

The CHAIRMAN announced that the next meeting would take place at **8 p.m.** on **Tuesday, April 20th,** when a paper on **"The Artificial Lighting of Churches"** would be read by Mr. J. DARCH.

* ILLUM. ENG., March, 1920, p. 65.

MOTOR-CAR HEADLIGHTS AND REARLIGHTS IN RELATION TO TRAFFIC REQUIREMENTS.

By J. W. T. WALSH, M.A., M.Sc., A.M.I.E.E.

(Introduction to a Discussion at the meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, March 30th, 1920).

THE subject which we are to discuss this evening is one which has long occupied the attention not only of the users of motor cars, but also of those who, as pedestrians or riders, use the roads where motor traffic is to be met with. Two points of view have at once to be clearly recognised ; the first is that of the driver who requires from his headlight sufficient illumination of the objects ahead of him, and that at sufficient distance, to enable him to avoid collision ; the second is that of the rider or pedestrian who requires that his eye shall not, by reason of the powerful headlight beam, be rendered incapable of perceiving objects to the side and rear of the oncoming car. It is also obvious that, without special arrangements, these two requirements are mutually incompatible. The ordinary form of headlight beam, if it is to be powerful enough to illuminate objects at a sufficient distance ahead of the car, must necessarily be such as to dazzle the eyes of anyone approaching it, and so render him incapable of perceiving any other objects in the immediate neighbourhood of the car.

In 1911, a paper on the very subject that we are now discussing was read before this Society by Dr. Hickman, and before that time orders had been made in which dazzling headlights were condemned in certain cases. The Royal Automobile Club in July, 1909, carried out a series of tests at the Crystal Palace with the object of investigating the question of glare from motor-car headlights.

In 1912 and 1913 the subject was under very careful consideration by the Local Government Board, and at their request an extensive series of experiments was carried out at the National Physical Laboratory with the object of determining whether it was in any way possible to avoid the dazzling effect without sacrificing too much of the illuminating efficiency of the beam. One of the suggestions put forward was that of blocking out the upper right-hand quadrant of the beam so that the lower half was left to illuminate the road and objects upon it up to about the 42-inch level, and the upper left-hand quadrant was still available to illuminate the near side of the road, with its signs, hedges and so forth. The upper part of the approaching rider, however, who would be on the right side of the road as seen from the car, would receive none but the direct light from the front of the source, *i.e.*, sufficient to enable him to recognise the presence of the car, but not enough to cause any dazzling effect on his eyes. The method by which this result was obtained was that of inserting a small quadrantal screen close to the source (whether it were an incandescent filament or an acetylene flame), and between it and the mirror. The effect is shown in Fig. 1 which is a photograph taken with two motor-car headlights which, together, over the main portion of the beam were equivalent to 1,400 candles. In the obscured segment, however, this intensity was reduced to 14 candles without any

appreciable diminution in the main part of the beam. This device, which was due to Mr. C. C. Paterson and Mr. B. P. Dudding, has been referred to as the "three-quarter beam."

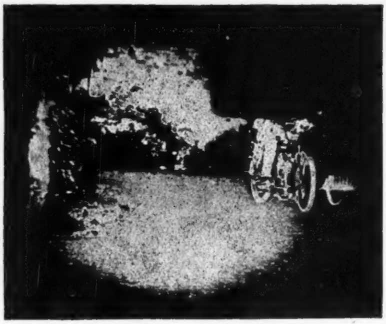


FIG. 1.—Showing the principle of the "three-quarter" beam.

An alternative arrangement is that by means of which the beam is confined, as far as possible, below the horizontal. This may be done either by a succession of deep louvres in front of the lamp, as shown in Fig. 2 or preferably by an

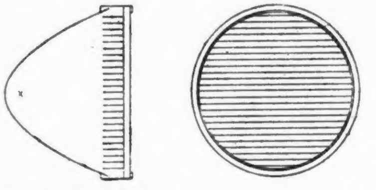


FIG. 2.—Use of louvres to confine beam below the horizontal.

arrangement of prisms which deflect that part of the beam which would otherwise be cast upwards, and cause it to reinforce the lower part of the beam which illuminates the road and all objects below the level of the headlight itself. Such an arrangement is illustrated in Fig. 3.

During the war, the question of dazzling headlights was overshadowed by the necessity of reducing all forms of exterior lighting to a minimum and the orders made under the Defence of the Realm Act aimed at reducing the total intensity of the beam to the lowest possible limit consistent with safe driving, without regard to any limitation of the form of the beam to avoid dazzle.

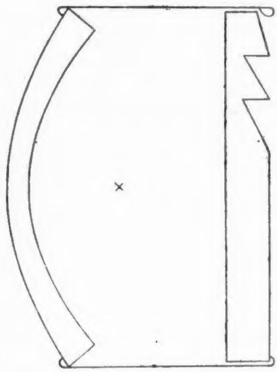


FIG. 3.—Use of prisms to deflect rays which would otherwise be cast upwards.

Now, however, the matter is again receiving attention and it has been considered by a Committee set up under the Ministry of Transport. This Committee has just issued an interim report in which (as reported by "Modern Transport") it makes the following statement: "With regard to headlamps on motor vehicles, whilst the Committee are still pursuing their investigations with regard to this question, and are not in a position to make any definite recommendations with regard thereto, they think it may be of interest for them to state that the evidence they have heard, and the results of tests that have been carried out, strongly point to the following conclusions, viz.:—

"(1) No satisfactory practicable dimming device to avoid dazzle has yet been discovered. Such devices which avoid dazzle to any appreciable extent unfortunately fail to give a safe driving light, and also, of course, cause an extremely large percentage of loss of lighting power.

"(2) Far too powerful headlights are in comparatively common use at the present time.

"(3) Pending the discovery of some satisfactory dimming device, a maximum power light, sufficient to give a safe driving light, should be fixed, and the reflectors in the case of all lights should

be limited in size, varying in accordance with the power of the light."

It will be noticed that the Committee promise further investigation of the matter, and presumably this will lead them to some rather more definite recommendations or suggestions. The whole subject of headlights has been very thoroughly dealt with by a Committee of the American Illuminating Engineering Society, and their Report, issued last year, gives a very full description of experiments bearing on the question both of the minimum light required for driving, the brightness of a light source causing dangerous glare, and the possible means of reconciling these two opposing factors in the same headlight.

I think it will be of considerable assistance to us in our discussion of the subject this evening if we have before us a short summary of the report of the American Committee. After considering at some length the requirements to be fulfilled for safe driving, and the various factors entering into the subject of glare, they describe the optical principles underlying headlighting and the production of a satisfactory beam. The practical conditions met with, such as curving and uneven roads, crossings, sign boards, road margins, foliage, street lights, dust, fog, rain and snow are all considered. Their final recommendations are as follows:—

"*The Headlight Beam.*—No headlight should be permitted such that the reflected or beam light is projected above a plane 42 in. (107 cm.) above the road and parallel to it, measured 100 ft. (30·5 metres) ahead of the vehicle. We do not consider it advisable to place a maximum limit upon the lateral spread of the beam provided it is confined below the 42 in. level. Permitting light in the upper right-hand quadrant of the beam is still favoured by some, but the majority of your Committee favour limiting the beam to the lower quadrants, particularly in districts having numerous curved roads. The beams from spotlights should be subject to the same limitations as those from headlights.

"*Scattered Light.*—No light above the horizontal should be tolerated which, at 5 ft. (1·5m.) above the road surface, is of more than a certain candlepower. This Committee favours a limitation of this form, but considers that the precise candlepower specification should be subject to such modifications as may seem desirable in the light of further experimental work. The sharpest practical cut-off is desirable to minimise glare on country roads, since with dark surroundings the retina is so sensitive as to be easily blinded The practical limit is of the order of 100 to 500 candlepower 1° above the horizontal, or 5 ft. (1·5m.) above road level at 150 ft. (46 m.) The 5 ft level is specified rather than the usual 42 in. (107 cm.) level since we are concerned with glare chiefly at the average height of the eyes of pedestrians and the drivers of approaching automobiles.

"*Minimum Illumination.*—No driving should be permitted where the road illumination provided is less than 0·001 f.c. This limitation, of course, concerns chiefly the safety of the driver himself, but also the safety of pedestrians and the occupants of unlighted horse-drawn vehicles.

"*Minimum Spread.*—The normal illumination provided at distances from 50 to 100 ft. (15·3 to 30·5 m.) ahead of the vehicle should not be less than 10 ft. (3·1m.) in width upon the road surface. With a sharply focused narrow beam and very little scattered light, passing other vehicles is dangerous because such a beam cannot illuminate both the vehicle passed and the edge of the road on that side.

"*Coloured Headlights.*—The use of white headlights should never be legally required since it cannot be enforced Even with uncoloured headlights no source of light even closely approaches white. Aside from the slight and unimportant colour distortion, your Committee finds no objections to the use of the yellow or amber coloured headlights."

Here we have clear and definite recommendations laid down, chiefly as regards the prohibition of a beam any part of which diverges more than 1° above the 42 in. horizontal plane, and the requirement of a certain degree of road illumination and the spread of the headlight beam. We may not necessarily agree with these conclusions in every particular, but they will at least, I hope,

form a basis for a very practical discussion on the subject of motor headlamps from the point of view of both the motor driver and the pedestrian or other road user.

These recommendations of the American Committee have been endorsed by the London "Safety First" Council, who last year made the following recommendations with regard to headlamps :—

"(a) No portion of the beam of light shall fall outside a plane parallel to and 42 inches above the roadway measured as a distance of 100 feet from the vehicle.

"(b) There shall be sufficient light to enable a person or object of substantial size to be distinguished at a distance of 100 feet ahead of the vehicle.

(This probably requires a beam of 500–1,000 c.p. if dark objects are to be distinguished at the distance specified. In these circumstances the illumination, at a distance of 100 feet, would be 0·05–0·1 foot-candles. In obtaining this value the design of the lens and reflector is more important than the candlepower of the lamp, but a suitably designed lamp consuming 10–15 watts of electricity, or an acetylene lamp consuming $\frac{3}{4}$–1 cubic foot of gas per hour, would probably suffice.)

"(c) The illumination produced on the roadway at a distance of 100 feet shall not sensibly diminish for a distance of 5 feet on either side of the centre of the beam.

"(d) There shall be sufficient side-illumination to reveal any person, vehicle or substantial object on either side of the beam or 10 feet ahead of it."

The regulations of the States of New York and of Connecticut are also interesting in this connection. In New York the qualifications of front and rear lights are stated much more fully than in this country. The latter rays must also shine upon the number plate so as to render the numerals readable for at least 50 feet. Front lights must be visible 250 feet in the direction in which the vehicle is proceeding, and if the street lighting is insufficient to reveal any person, vehicle or substantial object at a distance of at least 200 feet, then the front lights must be sufficient to do so Similarly any substantial object must be revealed by the light from the front lamps at a point ten feet on either side of the vehicle, if the street lighting is insufficient to do so.

In Connecticut it is laid down :

"(1) That no portion of the beam of reflected light, when measured 75 feet or more ahead of the lamps, shall rise above 42 in. from the level surface on which the vehicle stands.

"(2) Sufficient light to discern a person or substantial object 150 feet directly ahead of the vehicle.

"(3) Sufficient side illumination to reveal any person, vehicle or substantial object 10 feet to both sides of a vehicle, at a point 10 feet ahead of lamps."

The existence of such regulations shows us that there can be no insuperable difficulty in meeting such requirements, and in ensuring that they are complied with, and I hope that the outcome of the discussion this evening will be some very clear and practical suggestions as to the kind of regulation which is necessary, the possibility of complying with it, and the method by means of which such compliance can be tested if necessary.

The chief object of these introductory remarks has been to provide material for discussion, and it may therefore be convenient to summarise the various points raised in the form of a series of queries, as follows :—

(1) What value should be assigned for the minimum range of headlights, *i.e.*, what is the smallest distance at which a dark object of substantial size must be seen in order to allow time for the car to pull up, and avoid a collision ?

(2) What is the minimum illumination necessary to enable such objects to be clearly seen at the prescribed distance, and the corresponding minimum value to be assigned to the effective candlepower of the beam ?

(3) What should be the limits assigned to the width of the beam at the distance prescribed in (1) ?

(4) Should any recommendations be made in regard to the illumination afforded on the portion of the road lying between the car and the point of minimum range ?

(5) Is it desirable that the light from the beam should be confined below a certain horizontal plane, at a fixed

height above the roadway, and how should this plane be specified? Would it suffice if a limit were set to the candle-power in directions above this plane?

(6) Is it desirable that a maximum value should be assigned to the candle-power of the main beam with a view to limiting glare, in addition to the minimum proposed under (1) for the benefit of the driver

(7) Should supplementary requirements be made in regard to the light available in the area immediately adjacent to the car, *e.g.*, on either side of the car or ten feet ahead of it?

(8) Is it desirable that means should be provided whereby the driver can diminish the power of his lights, in cases where this appears justified by the available street lighting? or that headlights should be extinguished in important public thoroughfares, the lighting of which reaches a prescribed standard?

(9) Is it desirable that headlights should turn with the steering wheels, so that the direction of the beam affords an indication of the course of the car when it turns?

(10) Is it practicable to supplement the existing rear red light by some form of rear luminous signal indicating when a car is about to (a) slacken speed, (b) reverse gear and travel backwards, and (c) turn to the right towards the middle of the road?

(11) Is there any available information justifying the belief that the use of golden reflectors or yellow-tinted diaphragms promotes good penetrating power in fog and also diminishes the tendency for a luminous haze to be formed, interfering with the vision of the driver?

DISCUSSION.

Capt. E. Stroud said the problem of anti-dazzle of motor headlights was not an easy one to solve, but from the number of devices one saw published in the motor journals week by week it was apparent that it was being tackled by many manufacturers, and it only remained to sort out the wheat from the tares, by discussing the actual requirements and by seeing how far they were being fulfilled by the methods available.

He thought they might take it that consideration must be given from three points of view; first, the requirements of the driver of the car itself; secondly, the driver of the oncoming car; and thirdly, the needs of pedestrians and ordinary vehicular traffic.

A driver of a car requires sufficient driving light to enable him to pick out irregularities in the road and of sufficient intensity to pick up oncoming or overtaking traffic. He also requires sufficient sideway illumination to enable him to pass traffic in safety and to recognise the edge of the road and side turnings. The driver of the oncoming car requires to know as early as possible of the approach of another car, and it was essential that when being approached he was not blinded by the glare from the headlights of the other car.

Let it be assumed that it was necessary for a driver to pick up objects on the ground at least 50 yards ahead, then it was equally necessary to have that space from the car to the 50 yards distant also illuminated with a more or less equal intensity so as to see obstructions more near at hand. The requirements were: first, a good driving light which should not rise above the horizontal; secondly, good illumination from directly in front of the car to the maximum beam; and thirdly, adequate sideway spread.

On first consideration the problem might be thought to be solved by tilting the headlamps. Modern parabolic headlamps although not giving the theoretically parallel beam of light did give a very narrow beam of intense light which diverged about 2 degrees. If one tilted the headlamps one degree to point about 50 yards that still did not satisfy points 2 and 3, also one still got the intense beam for 2 degrees above the horizontal.

If one tilted still more than that, the driving light and sideway spread were not secured. There were several methods of dealing with glare, such as treating the bulb itself or treating the reflector but he only proposed to discuss those dealing with the front glass or lens.

Through the courtesty of Messrs. C. A. Vandervell, he had an exceptional opportunity of viewing a number of anti-dazzle lenses, fully rigged up ready for road tests. Road tests were necessary and essential, but might not be conclusive in themselves, therefore the lamps were kindly loaned to him so that he could take laboratory photometric tests which might help considerably in arriving at a conclusion of the respective merits of the series of lenses. From curves which he showed it might be seen whether they more or less met the requirements. These curves are reproduced in Fig. 1, and show the whole series of anti-dazzle lenses super-imposed on one sheet so that they are strictly comparable as to vertical distribution and intensity one with the other. With the tests the head-lamps were fixed in an horizontal position and photometric readings were taken at various angles through the vertical axis of the lamp. The curves were plotted with the candlepower intensities above and below this vertical axis, in degrees. The degrees were shown as horizontal lines instead of the usual radial lines, so as to bring out more clearly the performance of the lens.

The first two curves shown (not included in the graph) were of metal devices and according to the tests did not throw the maximum light below the horizontal.

The Dillon lens, Curve " A," is rather a massive lens, formed like a truncated cone with the crater centre in which is a bull's-eye, the sloping sides of the cone are matted and the flattened top is formed a series of vertical lenses. The maximum candle power 5,800 is given at 1 to 2 degrees above the horizontal.

The Macbeth lens, Curve " B," has a glass projection at the top, green enamelled, in the form of a visor, the rest of the lens has a pronounced square-shaped prism formation. The test shows a maximum candlepower of 8,280, but in a horizontal direction.

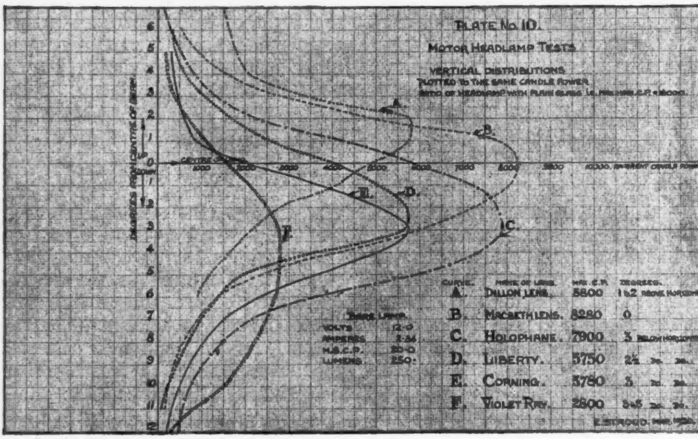
The Holophane lens, Curve " C," is in the form of a flat plate. On the side facing the lamp is formed a series of sets of prisms each series designed to control portions of the light beam. Extending backward on this side just above the bulb of the lamp, projects a fin of specially treated glass. On the top portion of the lens, the horizontal prisms refracts the upper rays downwards. Just under the fin, but in the upper half, are two sets of prisms shaped somewhat like the rising sun with extending rays, the centre bull's-eye prisms control the central rays, and the radial prisms bend rays to illuminate the side of the road near the car. On the lower half of the plate, prisms are designed to give distance to the beam. The vertical distribution curve shows that the maximum candlepower 7,900 is given at 3 degrees below the horizontal, with a fairly intense beam from the horizontal to about 10 to 12 degrees in a downward direction.

The Liberty lens, Curve " D," is a lens very similar to the Macbeth, but without the green visor. This lens gives a maximum candlepower 2 to 3 degrees below the horizontal, but with rather less intensity than curve " C."

The Corning lens, Curve " E," is a flat lens with a series of square-shaped prisms, the glass being golden-tinted. The light distribution is similar to curves " C " and " D," the maximum candlepower being 5,780 at 2 degrees below the horizontal.

The Violet Ray lens, Curve " F," has a dark enamelled visor somewhat similar to the Macbeth, the lower portion being formed into a series of sets of prisms on both the inside and outside. The glass is rather violet in tint, which apparently cuts off a fair amount of the driving light. The maximum candlepower shown is 2,800 at 3 to 5 degrees below the horizontal. A further curve shown, not included in Fig. 1, was that of the Osgood long distance lens. This lens gave a distribution of the same characteristic as the plain parabola, therefore would not come under the category of an anti-dazzle device.

The curves he now showed (Fig. 1) might enable one to gauge the possibilities of refraction as a solution to the problem, but they were not complete, as the side



. FIG. 1.—Showing distribution of light from various types of headlights.

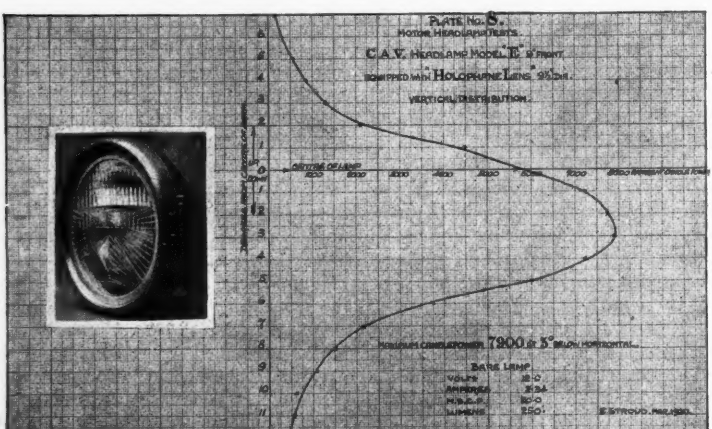


FIG. 2.—Illustrating appearance and distribution of light from Holophane headlight lens.

spread of light was not shown. A tremendous number of readings would have to be taken to obtain the hemispherical distribution, the light distributions being asymmetric. Also it was difficult, for the same reason, to measure the total output of the equipment so as to get at the total efficiency. He tested the bare lamp for actual candlepower and obtained 20 mean spherical candlepower, which equals 250 lumens.

With the head-lamp equipped with parabola only, no glass front, he got 150 lumens, which was about two-thirds. He now showed a slide taken from three lenses which were in keeping with his contention that the maximum beam should be about 2 to 3 degrees below horizontal. At an angle of 1 degree, the candlepower values of the Holophane, Liberty and Corning were 7,200, 5,000, and 3,500 respectively.

The figures for other angles and distances were given in the following tables:

NORMAL ILLUMINATION VALUES CALCULATED AT DISTANCES WHERE VARIOUS ANGLES STRIKE GROUND.

Angle below Horizontal.	Distance in Feet.	Type of Lens.					
		Holophane.		Liberty.		Corning.	
		C.P.	Ft.C.	C.P.	Ft.C.	C.P.	Ft.C.
1°	144	7200	·35	5000	·22	3600	·16
2	72	7750	1·5	5700	1·1	5100	1·0
3	48	7900	3·4	5700	2·5	5800	2·5
4	36	7300	5·6	3500	2·7	5100	4·0
5	29	6000	7·2	2000	2·4	3700	4·4
6	23·8	3600	6·4	1400	2·5	2400	4·25
7	20·4	2200	4·5	1000	2·0	1500	3·1
8	17·8	1500	4·7	700	2·2	1000	3·14
9	15·8	1100	4·4	450	1·8	700	2·8
10	14·2	750	3·7	200	1·0	500	2·5
11	13·0	550	3·3	100	·6	300	1·8
12	11·8	450	3·2	50	·36	200	1·4

Horizontal plane—2 ft. 6 in. from ground level.

One got practically even illumination from the distance where the maximum beam met the ground, and he thought that the three lenses in question more or less met the requirements.

He wished to express his thanks to Mr. Goodwin and Mr. Brown of Messrs. Vandervell for loaning him the head-lamps with lenses, and also to his colleague Mr. Tye for his assistance with the tests and photographs.

Mr. B. P. DUDDING, referring to the so-called "three-quarter beam" device, said it should be pointed out that at the time Mr. Paterson and he worked on this problem parabolic mirrors were not in the majority, as they are at present, and most of the investigation was done with the Mangin mirror lens. The device actually used was not directly applicable to the parabolic mirror.

The top left-hand portion of the beam was retained, as a large number of drivers maintained that it was necessary in order to make it possible to see the hedge and the road signs. A drawback to the arrangement was that, unless roads were reasonably straight, every time a crescent was turned, the beam was brought across the road and dazzled the eyes of oncomers. The Americans had decided to legislate for a beam giving no light above the horizontal. At the N.P.L. they had some difficulty in conducting experiments on devices designed to ensure this condition. The ordinary brackets for carrying lamps on cars were not designed to give the fineness of adjustment necessary for such work. Further, even if arrangements were made for cutting off practically all light above the horizontal, it was easy to throw up the beam a degree or so by changes in the loading of the car. The recommendations of the Transport Committee were quoted in the paper, but were worded ambiguously. Referring to Item 3: "maximum power of the light" was a very vague statement. Do they refer to the power of the beam, or to the source of actual light in the lamp itself? There was no point in limiting the power of the light which can be put into the lens system. The whole thing depended on the optical arrangements. Any limitation proposed should be referred to the

beam. At the National Physical Laboratory they made experiments to determine at what distances objects of different surface brightness could be picked up on an ordinary tarred road, and definite results were obtained. A figure was assessed to the illumination that was required to enable one to see a person in dark clothes on a tarred macadam road.

Laboratory experiments which were in progress when the investigation ceased indicated another possible method of reducing the effect of "glare." In the experiments a small tungsten lamp was set up to act as the "glaring" headlight, and a man-shaped figure, whose surface brightness could be varied at will, was arranged so that an observer, looking towards the glare lamp, could cause it to move at right angles to his line of sight. The line of travel of the figure was slightly behind the lamp. The whole arrangement was viewed from such a distance that the figure subtended the same angle at the eye as a man at a distance of 200 ft.

It was found that the figure when moved across the line of sight towards the glare lamp vanished quite sharply at a certain distance from the glare lamp. This distance depended on the brightness of the figure. These results indicate that if a car carried lights which strongly illuminated the ground behind the car on the right hand side, the "glare" effect of the headlights of the car would be considerably reduced. These rear lights would of course be arranged so that they did not throw any light above the horizontal. This would not be difficult as close adjustment to near the horizontal would not be necessary, in this case, where the range of the light on the road need not be large.

Mr. Elyard Brown said that he believed that the tests conducted by the Royal Automobile Club in 1909 did not deal with the question of dazzle. The chief aim of those who took part in these tests seems to be to obtain the maximum carrying power of beam. There was no doubt that much unnecessary glare existed in present types of headlights, especially those using electric light, the lamp in many cases being ill-adapted to the size and depth of the reflector. The shallow reflector used on many American cars gave more glare than did the relatively deep ones more usual on British cars. Generally speaking, the maximum candlepower should be proportional to the diameter of the mirror, *i.e.*, not more than 24 candlepower in a 7-in. reflector, nor 32 candlepower in an 8-in. or 9-in. reflector, nor more than 48 candlepower with a 10-in. reflector.

Glare, in effect, was a physiological state of the eye arising when one was confronted by a bright light, so that one could not see objects behind it. But there was also a psychological aspect, which might be described as "light-shock"—a kind of unreasoning irritation. The effect was less marked if the adjacent illumination was good, but a person in a dark lane might be dazzled even by the lamps using candles employed on a doctor's brougham.

It seemed clear that the difficulty in obtaining a form of headlight which enabled one to drive safely and yet caused no inconvenience to other people was almost insuperable. Some of the headlights which he had been testing a few nights ago did, however, go a considerable way towards meeting this double requirement. They aimed at a redistribution of light, and confining it mainly below the eye-level. Entire extinction of light above the eye-level, such as was apparently contemplated in some of the American regulations, was not only difficult, but also, it seemed to him, undesirable as it would result in projecting loads on vehicles being completely obscured. The effect was also unnatural. The ideal was to observe objects by a diffused illumination, so that one approached by night the conditions prevailing by day.

While motorists were under an obligation to avoid causing unnecessary inconvenience to other people, a duty also rested on pedestrians and drivers of other vehicles to aid the drivers of motor-cars, particularly by rendering themselves and their vehicles as easily visible as possible.

As regards colour, a light in which blue and violet were predominant was not only bad for driving but also gave rise to unnatural effects in revealing the colours of objects illuminated.

Reflecting devices, such as the Holophane, Liberty, etc., diminished the direct light and effected a redistribution by deflecting the main beam downwards. Various forms of dimming devices, which diminished the lights, had been used. Introducing resistance in series with the electric filament was a somewhat cumbersome method; a more effective device was the use of a small switch which dimmed the light by putting two headlights in series. This, however, caused the side-lights to become unduly prominent and thus a source of glare and they required dimming as well. The use of such a series-parallel switch should be obligatory under prescribed conditions; otherwise the motorist who adopted this method suffered from the headlights of other cars which were not so treated. The difficulty in passing an approaching vehicle was due to the contrast between the glare of the headlight and the relative darkness behind the oncoming car. He had tried a device which he found effective, namely, to have a fairly powerful tail lamp and an offside spot light more powerful than usual so as to illuminate a patch of road on the offside to the rear of the car. This device gave a man just that extra confidence in passing another car which he would otherwise lack. Many American cars had the number and the lamp on the offside wing, thus illuminating a small area of road as well as the number.

An idea that had been tried in the recent tests was to attempt to colour the upward beam. This was done by putting transparent green varnish on the underside of the bulb, and a beam so coloured seemed less irritating than a white light.

Major A. Garrard remarked that he had come rather with the idea of listening to the views of the lighting experts present than with the intention of contributing to the discussion, and his remarks would therefore be in the nature of further questions. He said the United States regulations were very indefinite, although they all tended in the direction of decreasing the upwards illumination. He could not understand how the police authorities could carry such regulations into effect. Some more definite standard of illumination was wanted in this country. With regard to the diagrams from the various lenses giving the illumination at various angles above and below the centre line of the lamp, it seemed to him that they were all very similar in regard to the light distribution, and differed chiefly in that the direction of the centre of maximum illumination was in some cases central and in others several degrees upwards, so that similar driving results might be expected generally by tilting to different angles.

He had heard of no suggestion as to any method by which the practical results given by these various devices could be readily tested. He would like to hear more about simple practical photometric methods of testing the illumination at various distances in front of the car and towards the sides. This matter was of interest to those who might be concerned in the framing of regulations which would have to be administered by the Police.

The discussion was started on with two almost diametrically opposed objects in view—to illuminate for a considerable distance ahead, and to avoid inconvenience to the driver of another car, or to a pedestrian who met the headlights. One requirement a pedestrian would make was that he should be able, when facing the headlights, to see objects at the side of and behind the car; he did not see how this could be done with an almost point source of light, a reflector of only about 7 in. diameter, and no illumination on either side of or slightly behind the car.

Mr. H. Salsbury drew and explained diagrams of his lenses. The type "A," which he said was similar to the louvre, was constructed of strips of glass built up and cemented together, and its faces cut and polished. The underside of the strips was finely ground, and the top left polished, so that light which struck upward was reflected downward at the same angle. Parallel light went right through the prism, and any downward light was absorbed. Another type of lens "B" which he showed was the prismatic. By making the prism more acute the refraction could be got to any desired angle. A little illumination was given above the horizontal, which gave the driver a safer feeling than if

the upper rays of light were cut off quite abruptly. Both these types were tested at the National Physical Laboratory and gave a very good reading.

Sir LANCELOT HARE said the light could be controlled by means of a shade. If a shade were placed a little way over the lamp the light would not rise but was reflected downwards. The result was that the rays of light were kept at a definite height above the ground, as the Americans required. If one wanted to light ahead, the light would be reflected along the ground, starting from a height of 4 ft. or so as the Americans fixed it, and remaining at that height so long as the car remained horizontal Similarly, if the shade were extended to the sides of the lamp, it could be made to give just the width of light required. It did not matter how strong the light was, provided it was strong enough to throw a light as far as required. Anybody whose eyes did not come within the path of light would not be dazzled. The light lit up the particles of dust, and these reflected light so that anyone outside the path of light knew where it was. There was no glare annoying to anyone whose eyes were outside the beam or rays of light, but only if one's eyes were inside the beam one got the dazzle. Anyone whose eyes were not less than 4 ft. above the ground would not have his eyes within the beam of light and so would not be dazzled.

If the beam of light is kept within 4 ft. of the ground it does not seem necessary to control the width of the headlight or forward beam of light from the point of view of a pedestrian whose eyes would always be over 4 ft. from the ground. But if it is desired to throw the forward beam further, then concentration of the side-spreading rays would give a stronger forward light.

On a switchback road (and all roads are more or less switchback) the light would be found to move up and down, and this on a very uneven road might annoy the driver. It would also throw up the light over 4 ft. frequently, and dazzle the eyes of a pedestrian. The wider the path of the beam the more pedestrians it could catch.

It would probably be an improvement to place the headlight higher than 4 ft., viz., on the top of the screen, and to direct the beam so as to strike the road at the distance required when the car is itself horizontal and standing on a horizontal road. A little consideration would show that it would be very easy for a pedestrian to get outside the path of such a light if it were of narrow width, as he would have warning that it was coming.

The old coach lights were always put up high, but coaches travelled comparatively slowly, and fresh experience is necessary.

It would be very easy to have the shade under control and to lower or raise it, and also to move it sideways to counteract the action of a switchback or zigzig road. This would give power to direct the light in certain cases of bad turns or slopes.

The true solution of car lighting seemed to be three lights—two side lights to give diffused and not glary light for some 20 yards each side and in front, one headlight to throw a controlled and concentrated beam of light ahead to the required distance.

Mr. F. NEWTON (Engineer to the Automobile Association & Motor Union) was of the opinion that before arriving at the degree of light restriction possible, consistent with safety to the driver and to other users of the road, it should be agreed upon as to what maximum road speed should be considered as essential or permissible when driving at night under favourable conditions, from which could be readily determined the minimum distance ahead which objects on the road could be safely picked up, and in this connection he suggested a speed of 30 m.p.h. and a distance of 80 yards. With these essentials agreed upon, all suggested dimming devices should be of a nature to permit of the driver seeing such agreed distance ahead clearly.

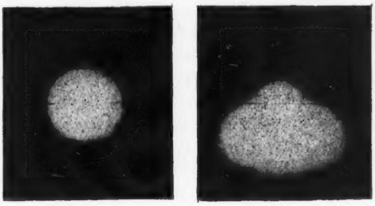
Many of the patented dimming devices that had been shown and demonstrated were very efficient—in the majority of cases too much so. They were also expensive and not readily adaptable to 40 or 50 thousand existing lamps, for example, if required. On the other hand,

there appeared to be several simple devices such as pyramidical glass, frosted glass, frosted bulb, etc., which are readily procurable and adaptable, and which from driving tests have been found to enable the above conditions to be complied with, at the same time materially lessening glare.

Mr. L. M. TYE showed a slide, reproduced below, which indicated the extent to which glare has been suppressed by the use of optical devices such as the Macbeth and the Holophane lenses, shown in comparison with the blinding effect of the modern unprotected headlight. The method of design effected this result without creating a large absorption of the light, the main beam being so refracted as practically to eliminate those rays which emanate above a horizontal line.

Another slide illustrated this refraction in the case of the Holophane lens more clearly and, in addition, showed the way in which the beam is broadened, thus giving better sideway illumination. It was interesting to note how closely these photographic results confirmed the results expressed in Captain Stroud's actual photometric tests.

The design of the Holophane lens was of an interesting nature. There were a series of bulls-eye prisms in the centre to control the central rays. At the sides there were prisms to give sideway spread and below, surfaces to give distance to the beam. A further feature was the fin affixed to these lenses about two-thirds the way up which greatly assisted in eliminating the upward rays.

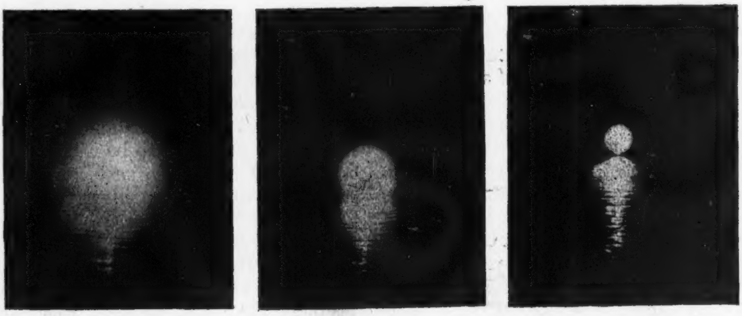


Ordinary parabolic beam. Ordinary beam transmitted through Holophane lens.

FIG. 2.

The CHAIRMAN (Lt.-Col. F. A. Cortez Leigh), who explained that he was unavoidably called away at this stage of the proceedings, expressed his appreciation of Mr. Walsh's paper, and of the contributions of various speakers. He agreed with Mr. Newton that it was desirable to attempt to devise modification which could be applied to existing headlights, with a view to diminishing glare. The investigations being conducted by the Ministry of Transport would be watched with great interest, and the Illuminating Engineering Society would be pleased to co-operate with the Ministry in this and any other enquiries concerned with lighting.

Mr. LEON GASTER (Hon. Secretary), who then occupied the chair, referred to Major Garrard's remarks. The question of determining convenient and simple means of testing the qualifications of headlights was admittedly not an easy one, although the introduction of simple forms of illumination photometers made



Ordinary headlight. Ordinary headlight with Macbeth lens. Ordinary headlight with Holophane lens.

FIG. 1.

it possible to test the candlepower of a beam much more readily than in the past. Their primary object in this meeting, however, had been to ascertain the precise conditions to be met by a satisfactory headlight. Having determined these requirements, the next step would be to work out a suitable method of testing its performance.

Wing-Commander T. R. CAVE-BROWN-CAVE (R.A.F.) said that the effect of dazzle appeared to be due mainly to the fact that a large amount of light was emitted from a relatively small area. He thought that the effect might be better if, instead of having two large headlights, there were a considerable number of sources, giving the same total candlepower but distributed evenly over the front of the car. If all the upper part of the beam were cut off it would cause serious difficulty on an undulating road or when passing a sharp corner. In order to avoid the glaring effect of an opposing powerful headlight he coloured a corner of the wind-screen a very dark green and managed to keep the approaching driver's headlights within this coloured patch. By this simple device, which only cost sixpence, he was able to continue at full speed without the necessity of slowing down owing to the dazzle of approaching lights.

Mr. A. CUNNINGTON said he thought the question of the amount of illumination required to discern objects at a distance required more experiment before definite figures could be put forward, and he would be glad to hear the results of the experiments described by Mr. Dudding. The American Committee said in paragraph (*b*) "there shall be sufficient light to enable a person or object of substantial size to be distinguished at a distance of 100 ft. ahead of a vehicle." That probably required 500 to 1,000 c.p. giving illumination of ·05 ft. candle up to ·1 ft. candle. That was the only definite figure he could find in the Paper. Later there was a suggestion that in Connecticut sufficient light should be provided to discern an object at 150 ft.

A figure he obtained in regard to railway shunting might be of interest. A truck was moved slowly out of the darkness towards the light, and the concensus of opinion amongst shunters, porters, inspectors and various people, was that an illumination of ·01 ft. candle was the minimum at which one could distinguish the dark end of a coal truck coming towards the illuminated area. He measured the vertical illumination at the point where the truck became visible, and if one allowed a factor of safety of 10 it looked as if the ·1 ft. candle suggested by the Safety First Committee would be ample for distinguishing a dark object at the distance of 100 ft.

Surely the candle powers mentioned by Captain Stroud were unnecessarily great. It rather bore out what was said in the Paper to the effect that far too powerful headlights were in comparatively common use at present. He thought Capt. Stroude's figures worked out at something like 0·5 foot-candles at a distance of 144 ft. There was a considerable difference between that and the 0·1 ft. candle, which latter figure was 0·1 times more than that actually obtained from the moving trucks test.

Mr. A. E. PARNACOTT said he had frequently averaged between 20 and 25 m.p.h. in the dark unlighted streets with paraffin lamps, and had had no accidents. He found he could get protection from the glare of headlights by shielding his eyes with his hand. The object of headlights was to illuminate the way, obstacles and pot holes in the road. He had also used powerful acetylene lamps mounted high above the driver and found it trying to the eyes. Better results were obtained by having the lights as low as possible, when the shadow of a stone or pot hole assisted vision. If the lights did not illuminate the trees, houses, etc., to some extent it was easy to lose one's way, for the profile or skyline seemed to play an important part in remembering a route. In a fog he preferred to be without headlights, and to have such as paraffin lamps that would shine sideways on to the hedges.

Mr. H. H. THOMPSON said they had somewhat minimised the fact that the problem they had to deal with was a composite one and could not be solved

by laying down any arbitrary rules of light. There were three parties to it, the car driver, the on-coming car driver, the pedestrian and slow moving traffic.

From the driver's point of view, a long driving light, particularly with fast cars, was a necessity; equally was it necessary that the light be so controlled that passing drivers could see without discomfort. The foot passenger and slow moving traffic cared nothing for a long driving light, but insisted upon a car being lighted in such a way that no discomfort would be experienced by the eye when looking towards the light at a reasonable distance away from the car. Some of the speakers had dealt with the matter from the car standpoint, but none had referred to the interests of the pedestrian, and the opposing nature of the requirements of the various parties concerned showed that the solution of the difficulty could only be obtained by a compromise which resulted in a continuation of a long beam with sideway distribution in conjunction with such a control of the harmful light as to meet the needs of the pedestrian. If a law were passed regulating the control of motor lighting he joined with Major Harwood in his expression of the difficulty of conveying to the officials concerned a simple means of deciding whether advice embodying such a control was within the law or not. In the U. S. A. almost every state had a law governing the matter, but the difficulty referred to had made it to a large degree impossible of enforcement. Despite this however the almost universal use of special lenses or other devices had resulted in an immense improvement generally.

Mr. C. H. Worsnop said that 20 years ago many of the questions now being discussed were already being debated by manufacturers. It was said that anti-dazzle devices were necessary, but the trouble was that there was a general demand for a powerful beam and the public would not consent to the expense of these special devices. Neither a policeman nor any other man could tell the candlepower of a beam without making a measurement. On the other hand he could, by experience, decide when a headlight was comfortable to pass, and he (Mr. Worsnop) thought that this condition could be met by the use of a simple reflector without any special lens. He believed he was the first to make a suitable reflector for use with an electric lamp, giving a beam of suitable carrying power, parabolic in the centre with softer light at the sides.

Mr. A. W. Wyatt remarked that the impression of glare was mainly a matter of contrast. A lamp in Cheapside would not have the same degree of glare as it would when seen in a dark country road, and similarly a headlight might appear dazzling on a dark night but not so when there was bright moonlight.

Mr. L. Gaster (Hon. Secretary) said that the difficulties of driving by night were closely related to the street-lighting. In London, as was well known, the conditions of lighting lacked uniformity, and in the interests of motor-traffic it would be a great help if it could be done systematically, and on a uniform basis, under some central authority conversant with the traffic requirements. He had frequently conducted foreigners through the streets of London by night and they had invariably been amazed to find that London was not one but many cities, each having its own different method of lighting. The contrasts within the London area were quite marked, and were even more so when one passed from Greater London to the suburbs.

It seemed to him that when approaching a well-lighted town motorists might well diminish the brightness of their headlights, or even extinguish them entirely in a well-lighted street and rely entirely on the side lights and the street-lighting.

He thought there was an opening for the more general use of special luminous direction-signs by motorists. When he had been in the United States he had been struck by a device which caused a warning rear lamp to be lighted automatically when a car stopped and began to reverse its direction. In the daytime, a motorist could give warning that he proposed to turn to the right or left by extending his arm. There was a need for a simple luminous device to be used by night. He thought a suitable device on the lines indicated in Mr. Walsh's tenth query (namely, some form of rear luminous

signal indicating when a motorist was about to slacken speed, reverse gear and travel backwards, or wished to cross the road), would be most useful.

With regard to the various regulations of American States, which Mr. Walsh had summarised in his paper, whilst these might not be applicable in their entirety he thought they formed a comprehensive study of the subject, and afforded a very useful basis for discussion. It might not be possible to satisfy both drivers and pedestrians completely, but we ought to be able to do better than at present. The degree of dazzle that could be tolerated by the average eye could be ascertained physiologically, and the problem should be treated on this basis. There were a number of factors to be considered, notably weather conditions, and the Ministry of Transport naturally required time before coming to a decision. The Illuminating Engineering Society would be very glad to be of assistance in their enquiries.

In conclusion he wished to express a cordial vote of thanks to Mr. Walsh for having undertaken to open the discussion at short notice, and also to the various gentlemen who had taken part in the discussion and exhibited forms of headlights.

Mr. E. S. Dumont (*communicated*) :—I regret that I was unable to be present at the reading of Mr. Walsh's paper and feel that we are much indebted to him for the lucid manner in which he has placed this important matter before us.

In the Report of the Committee of the American Illuminating Engineering Society, summarised by Mr. Walsh, the "spot light" is mentioned. This, is a lamp mounted on the side of the wind screen nearest to the driver and has a bracket movable in both horizontal and vertical planes, enabling a parabolic beam to be thrown in any direction. The lamp is used in conjunction with the two side lights, the latter indicating the exteme width of the car, the spot light throwing a beam down the road. This is economical as it eliminates the headlights in favour of the smaller "spot light." It reduces the glare to a minimum, and its mobility is an important asset. For instance, on dark roads it can be directed downwards at a sharp angle to the left and just ahead of the car to mark the edge of the road, and it can be used for reading road signs at night, distinguishing house numbers, etc. Notwithstanding all that can be said in its favour the use of such lights is prohibited under Article 2, Section VII. of the Motor Car (Users and Construction) Act of 1904. Much has been done since the date of this Order to improve illuminating devices, and it is to be hoped that the Report to be submitted by the Committee on Lights and Vehicles will contain recommendations which will bring the new regulations in line with existing requirements.

Dr. H. R. B. Hickman (*communicated*) :—With regard to the queries at the end of Mr. Walsh's paper I would suggest :

(4) Yes, this is a dangerous space.

(7) Yes, this also is a dangerous space.

(9) Yes, provided the beam is sufficiently wide.

(11) I still hold the opinion that there is less luminous haze in fog if the direction of the reflected beam is not immediately forward.

Mr. J. W. T. Walsh, in reply (*communicated*) :—I should like to thank the various speakers for their remarks of appreciation, and to assure them that what has been said to-night will be of great value to us at the National Physical Laboratory if at any time we should be called upon to continue the work begun on this subject before the war.

I have been very much interested in Capt. Stroud's figures giving the performance of different types of headlights. There does not seem to be any very simple way of demonstrating graphically for a headlight the different characteristics which are of importance in forming an idea of its performance on the road. The only methods at present used are, first, that of the ordinary polar diagram and, second, and as I think, better, the diagram used by Capt. Stroud. It is possible that a valuable method, in the case of the headlights such as we have had described, in which the vertical distribution of the beam has been intentionally distorted, would be the use of

a similar diagram showing the light distribution in a horizontal plane, or in a plane tilted downwards one degree from the horizontal. The most ready method of obtaining such diagrams is, of course, that of a portable photometer. As in all tests of projector sources it is necessary to ensure that the measurements on which the curve is based have been made at a distance from the projector sufficient to render negligible any departure from the inverse square law owing to the optical characteristics of the projector.

A useful figure to have, in addition to these distribution curves, is the average (or mean spherical) candlepower of the headlight. This gives, in conjunction with the same figure for the bare lamp, a measure of the proportion of light lost in the projector.

In reply to Mr. Cunnington, the figure of illumination for visibility at 200 ft., suggested as the result of the National Physical Laboratory experiments, was 0·1 foot-candle. The tests described by Mr. Dudding showed how useful was the off-side illumination suggested by several speakers. In passing, I may say that the figures of effective candlepower given by Capt. Stroud seem to me to be quite normal. An illumination of 0·1 ft. candle at 100 ft. means a minimum effective candlepower of 1,000 candles.

The difficulty about the device suggested by Wing-Commander Cave-Browne-Cave would appear to be that if the dark portion of the screen lowers the brilliancy of the headlights, it must also render still less visible the objects in the vicinity of the car.

I cannot see how the device suggested by Sir Lancelot Hare can possibly be of assistance at any but short distances from the lamp. It is well known that the divergence of the beam from a parabola with a properly focussed source is governed entirely by the ratio of the linear dimensions of the source and the focal length of the parabola. The rays leaving the bottom of the parabola, therefore, have the same divergence as those at the top, and if the whole beam from a 9-inch light has a total of divergence of five degrees, the screen would have to be 20×9 inches=15 feet long before it would affect the upward spread of the beam as seen from a distance.

In conclusion, I should like to thank once more all those who, by taking part in the discussion, have helped to throw light on what is really a most difficult and intricate problem.

AUTOMOBILE HEADLIGHTS REGULATION.

By Clayton H. Sharp and W. E. Little.

Dr. Clayton H. Sharp has kindly sent us, since the date of this discussion, a copy of a paper by himself and Mr. W. E. Little, which was delivered before the Joint Meeting of the American Institute of Electrical Engineers and the Illuminating Engineering Society in December last, and was subsequently published in the Journal of the Engineer's Club of Philadelphia. The paper contains a review of progress in this field in the United States.

There has been much legislation with a view to diminishing glare from headlights, but it was couched in indefinite form, and had little effect. More definite provisions were subsequently made requiring that no portion of the direct reflected beam measured 75 ft. or more ahead of the vehicle, should rise more than 42 in. above the level surface on which the vehicle is standing. It was difficult, however, to state the exact limits of the reflected beam, or to distinguish the reflected rays from those which come direct from the lamp filament. It is also recognised that if *all* the beam were so cut off it would be dangerous for driving.

Attempts were made accordingly to frame more scientific provisions. In St. Louis, a limit of glare was fixed at 1,200 candlepower, in Ontario at 800 candlepower. At this stage the committee of Illuminating Engineering Society in the United States took the matter up, one primary problem being to ascertain how much light was required for safe driving. The New York State

Law, then in course of revision, providing that headlights must render visible a substantial object 200 ft. away, was taken as the basis of experiment. Actual experiments on the light necessary to see distant objects were made, about fifty observers being employed. Experiments were conducted on a dark road. One set of headlights was set up at the point of observation with a view to ascertaining their value in enabling objects to be detected 200 ft. ahead. A second similar pair was set up 100 ft. ahead facing the observers, and to the left, representing the lights on oncoming vehicles and enabling a judgment to be made of their influence in causing glare. Naturally, for purposes of visibility, great variations were recorded. The lowest figure recorded was 1,200 candlepower, the highest 18,000. From the standpoint of glare the lowest estimate of the permissible candlepower was 80 candlepower, the highest, 800.

About this time the Secretary of State of New York applied to the Committee for specifications under which tests of headlights could be made. It was clear that the beam down the road should not have less than 1,200 candlepower, the lowest estimate recorded above. Similarly that the glare arising from the lights of an approaching car 100 ft. away should not be greater than that caused by 800 candlepower, the highest glare value accepted. Working on this basis the specification was drawn requiring that the candlepower of the beam between the horizontal and the road level at a distance of 200 ft. in front of the car should not be less than 1,200; and also, from the standpoint of glare, restricting the beam to 800 candlepower at a point 100 ft. ahead of the car, 7 ft. to the left of the axis of the car and 60 in. above the road level. It was also provided that the candlepower *directly in front of the car* and 60 in. above road level should not exceed 2,400 candlepower. This higher value was allowed bearing in mind the greater distance of test (200 ft. as compared with 100 ft.) Specifications covering these limits were adopted by the State of New York and have since also been adopted by the State of California. The Committee, however, have always felt that even this value might with advantage be exceeded, and have more recently recommended 4,800 candlepower as the minimum. Further, bearing in mind the need for revealing pedestrians on the road, and the curb, and possibly ditches, it seems desirable that the light on the right hand side should also be specified and accordingly, the minimum value measured 100 ft. ahead and 7 ft. to the right of the axis of the car has been given as 1,200. The State of Connecticut has adopted these latest recommendations, while the State of Pennsylvania has adopted the New York State Law, except that a minimum of 800 candlepower is required 100 ft. ahead of the car and 7 ft. to the right. There are thus four States which have adopted the Committee's ideas either *in toto* or in a modified form, and ultimately from the experience so gained a model headlight law should be developed with inter-state standardisation.

CHEVREUL'S WORK ON COLOUR.

We have received from Prof. C. M. Gariel, of Paris, some interesting information relating to the work of Chevreul on colour, some of which was summarised in a work by him published as far back as 1864, and entitled *Des Couleurs et de leurs applications aux Arts Industriels a l'aide des circles chromatiques*. This work, we understand, was issued in atlas-form. and served as a comprehensive guide to colour, by which any tint could be identified. As coloured-plates of this description are liable to change in course of time, Chevreul also reproduced the series in porcelain and the collection, Prof. Gariel believes, is still at the Conservatoire des Arts et Métiers in Paris. In appears that there also exists a collection of colours in worsted originally utilised by a company for the manufacture of gobelins, of which Chevreul was a director. In view of the early date of these researches the existence of such standard series of colours is most interesting, especially in connection with the recent discussion on the subject of colour-matching before the Illuminating Engineering Society.

A SURVEY OF INDUSTRIAL LIGHTING, Etc.*

By R. O. EASTMAN.

THE paper gives an account of a commercial investigation in the lighting field, and summarises the results of inquiries in fifteen States in America, conducted for the National Lamp Works. The survey covered a great variety of different classes of industrial enterprise, the largest proportion (16·1 per cent.) being textile, knitted goods and clothing, while food and toilet products (9·4 per cent.), general machinery (8·9 per cent.), lumber and woodworking (98·5 per cent.), and iron and steel (7·2 per cent.) form the next highest components.

Throughout the investigation the attempt was made by interviews with heads of business, managers, etc., to find out information and statistics on a number of points of great interest, such as the extent to which modern and efficient lighting was adopted, and if not why not; the views held regarding the advantages of good lighting installed; the percentage of hours worked under artificial light, etc. The experience is summarised in a series of diagrams, some of which are reproduced.

One of the most interesting sections is that illustrated in the three circular diagrams, Figs. 1—3. The first of these shows the percentage of men interviewed who were respectively intelligently informed, vaguely informed, and ignorant on efficient industrial lighting. That 44·5 per cent., or nearly half, were found to be well informed is a tribute to the methods of propaganda adopted in the United States; but as 20 per cent. were apparently entirely uninformed on the subject there is evidently room for further effort. Fig. 2 shows, in the same way, the relative importance attached to artificial lighting according to the judgment of men interviewed. Here more than half of the interviews revealed an appreciation that lighting was vitally important. Fig. 3 is interesting, as showing the extent to which regular cleaning and maintenance was adopted. Only 22·4 per cent. of cases showed that regular cleaning was practised.

Other interesting diagrams are of value to the salesman in showing who is the authority who deals with lighting, and is therefore the man to be approached. In most cases this falls within the province of the general manager (36·4 per cent.). Supplementary to this is a table showing in what quarters the firm would naturally seek information on lighting changes. The electrical retailer and jobber between them account for rather more than half, the consulting architect or engineer

* Abstract of a paper appearing in the *Transactions of the Illuminating Engineering Society* (U.S.A.), February 10th, 1920.

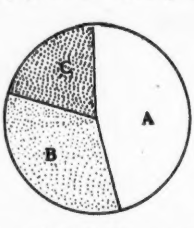


FIG. 1.—Knowledge of men interviewed regarding efficient Industrial Lighting.

		%
A. Well informed	..	44·5
B. Vaguely informed	..	36·4
C. Not informed	..	20·1

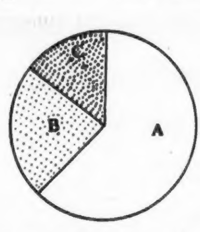


FIG. 2.—Importance of Artificial Lighting to the Business according to judgment of men interviewed.

	%
A. Vitally important ..	55·4
B. Moderately important	31·6
C. Of little importance .	13·0

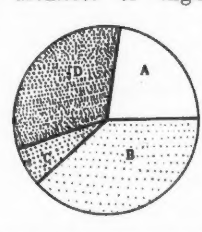


FIG. 3.—Cleaning of Lighting Appliances.

		%
A. Cleaned regularly	..	22·4
B. Cleaned irregularly	..	37·3
C. Cleaned frequently	..	6·3
D. Cleaned infrequently		34

figuring next with 13·2 per cent., and the central station with 7·2 per cent. Only 7·1 per cent. leave matters to their own electrician, and only 5·9 per cent. to their own architect or engineer. Summing up, the author shows that 72 per cent. would go to either their own electrical distributor or some one connected with their own organisation. It is remarked that of 446 institutions visited, the average cost of lighting during the summer months was $216 (approximately £50) per month, and in winter $613 (approximately £150) per month.

Perhaps the most useful diagram presented is that shown in Fig. 4, which estimates the present condition of lighting facilities, and thus gives a good indication as to prospects of improvement. Only about 9 per cent. were ranked as excellent in regard to lighting, but 32 per cent. and 29 per cent. were considered good and fair respectively. On the whole, only 40 per cent. of the manufacturing plants visited had lighting that could be considered good, and better illumination was needed in the remaining 60 per cent. of cases.

In this connection Fig. 5 affords a clue to the reasons why improved lighting is not adopted. It will be noted that by far the greater proportion (70·8 per cent.) did not seek improved illumination, because they were satisfied with the existing lighting. In other words, there is evident need of further educational measures to raise the judgment of what constitutes good lighting to a higher level.

One other point deserving notice dealt with in this paper is the proportion of time worked under artificial light in different industries. The time varied by artificial light from about 5 per cent. (in 17 per cent. of plants) to 95 per cent. in

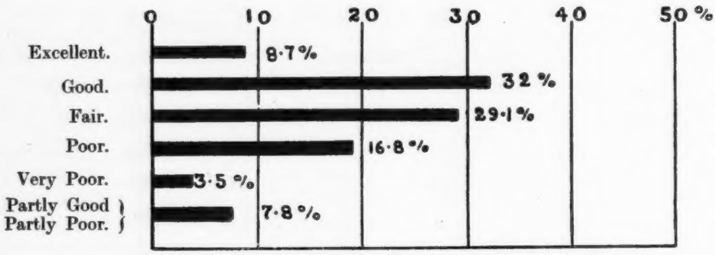


FIG. 4.—Present condition of lighting in plants visited.

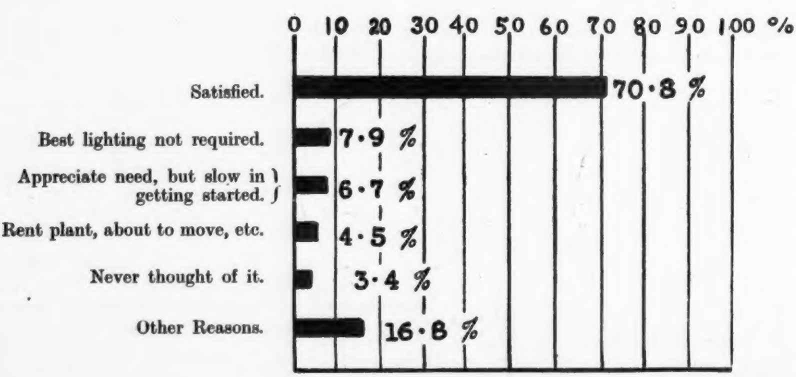


FIG. 5.—Explanation offered for failure to adopt efficient Industrial Lighting.

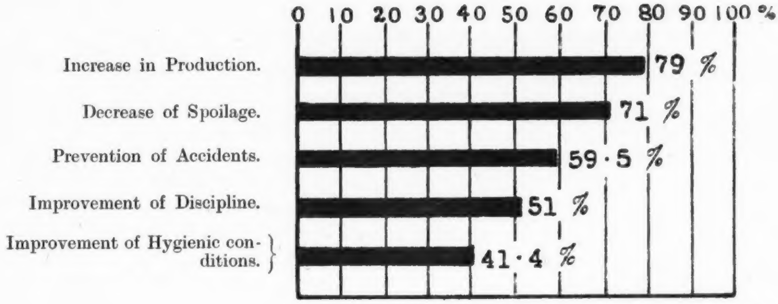


FIG. 6.—Appraisal by manufacturers of advantages to be derived from efficient Industrial Lighting.

about 3 per cent. of plants, the majority, about 70 per cent., working less than half time on artificial light. The average amount of work done under artificial light appears to be roughly 25 per cent.

Finally, we give in Fig. 6 the author's summary of testimony as to the advantages to be derived from good lighting. Curiously enough, the importance attached to the factors of increased production, less spoilage, prevention of accidents, improvement of discipline and improvement of health is almost exactly in the ratio, of 80, 70, 60, 50 and 40 per cent.—a useful indication to the salesmen of the points to be chiefly emphasised in approaching manufacturers.

In the course of the discussion Mr. Eastman was asked whether he had much trouble in obtaining this information, but replied that no great difficulties had been experienced, most of the managers interviewed being willing to talk about their lighting, as something in which they had a direct personal concern.

INDUSTRIAL LIGHTING AS AN AID TO MASS PRODUCTION.

In on article in the *Electrician* Mr. L. Gaster recently emphasised the important part played by lighting in connection with mass production. This mode of manufacture may involve work on the "three-shift" principle, so as to get the utmost output from the available plant and working area. The system, however, will only give good results if the artificial lighting is satisfactory so that work can proceed with the same efficiency by night as by day. On the other hand the Home Office Departmental Committee's report (1915) showed that the accident rate is in general greater by artificial light than by daylight, so that factory lighting is evidently capable of improvement. The tests made by the Commonwealth Edison Company in Chicago showed that increases in productive power of 8–27 per cent. were secured by an increase in illumination from 4–12 feet-candles, and, according to these tests, an increased expenditure on lighting equivalent to 5 per cent. of the wages-roll would increase output by quite 15 per cent. A diagram is presented showing that in a typical machine shop the cost of lighting formed only 1 per cent. of the cost of labour and only 0·3 per cent. of the total cost of production. Even a small gain in efficiency following improved lighting would therefore pay for the extra cost of improved illumination. In mass production there is usually an effort to standardise parts and render them interchangeable. The whole process may thus be upset if, owing to faulty lighting, parts are inaccurately made. Again, in a factory where each process of manufacture follows like clock-work on a predetermined system any accident or interruption of the chain of operations, such as might easily arise through inadequate lighting, is particularly serious.

THE FOUNDATION OF AN INSTITUTE OF PHYSICS.

The need has long been felt for a corporate body analogous to the Institute of Chemistry which would represent the profession and strengthen the position of workers engaged in physics, and which would also form a bond between the various societies interested. It is one of the aims of the new Institute of Physics to secure recognition of the position and value of the physicist. The Institute has been founded by the co-operation, in the first instance, of The Faraday Society, The Optical Society and The Physical Society of London, and the first Board is constituted from representatives appointed by the Councils of these Societies. It is hoped that in the course of time other Societies will associate themselves with the Institute. Members of the Institute, who are also members of more than one of the co-operating Societies, will obtain a reduction to the subscription to those Societies.

There will be three classes of members : Ordinary Members, Associates (A.Inst.P.), and Fellows (F.Inst.P.). Only the two latter classes, membership of which will require full professional qualifications, will be Corporate Members. The Institute has already received promises of support from leading physicists, and the initial expenses are covered by a Guarantee Fund amounting to over £1,200.

The first President of the Institute is Sir Richard Glazebrook, K.C.B., F.R.S. ; Sir Robert Hadfield, Bart., F.R.S., is Treasurer ; and Professor A. W. Porter, F.R.S., Honorary Secretary. The other members of the Board are : Dr. H. S. Allen, Inst.-Commander T. Y. Baker, R.N., Professor F. J. Cheshire, C.B.E., Dr. R. S. Clay, Mr. W. R. Cooper, Professor W. H. Eccles, Major E. O. Henrici, Dr. C. H. Lees, F.R.S., Mr. C. C. Paterson, O.B.E., Major C. E. S. Phillips, Dr. E. H. Rayner, Mr. T. Smith, and Mr. R. S. Whipple.

Mr. F. S. Spiers has been appointed Secretary to the Institute, and further particulars and Forms of Application for Membership may be obtained from him at 10, Essex Street, Strand, W.C.2.

THE UNIVERSITY OF MANCHESTER.

Funds for Increased Equipment and Accommodation urgently needed.

An appeal, framed on novel lines, is being issued by the University of Manchester for funds to facilitate an extension of work and new equipment. The appeal takes the form of a model prospectus entitled " Lancashire Development Unlimited," with a capital of £500,000 (425,000 cumulative participating ordinary bonds of £1 each and 1,500,000 cumulative participating people's bonds of one shilling), and each citizen is earnestly invited, by taking up bonds, to equip, endow and enrich the work of the University.

An account is given of the past work of the University, which has already played an important part in the educational scheme of this country, and is specially adapted to the needs of Lancashire with its important local industries. Of the money required £171,000 is to be absorbed by various specified objects, including the cost of and equipment of the New Arts Building, dealing with languages, literature, history and philosophy ; the purchase of two houses for women's hostels, and the endowment of three new chairs (already established) in Mathematics, French and Psychology, while two additional chairs in Russian and Italian are proposed. Expenditure is also needed in the reconstruction and equipment of the scientific departments and in providing for depreciation during the war, notably in teachers and equipment for advanced study and research, in connection with which the degree of Ph.D. has recently been established.

No words are required to emphasise the importance of encouraging the development of education and research in this country, and we trust that the appeal will meet with a generous response. Forms of application can be obtained from the Organising Secretary, Mr. Geo. A. Marriott (9, Albert Square, Manchester).

EXTENSION OF THE USES OF RUBBER.

The Rubber Growers' Association have decided to offer £5,000 as prizes, in the form of a competition for ideas as suggestions for extending the present uses or for encouraging new uses of rubber. There is one prize of £1,000, three of £500, ten of £100 and the remaining £1,500 will be allocated according to the value of suggestions. Particulars are obtainable from the Rubber Growers' Association, 38, Eastcheap, London, E.C.3.

INDEX, April, 1920.

TOPICAL AND INDUSTRIAL SECTION.

[The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

MESSRS. SIEMENS BROTHERS & CO. LTD.

NEW ARRANGEMENTS FOR LAMP SUPPLIES.

Messrs. Siemens Brothers & Company Limited inform us that they are taking over the Lamp and Supplies Department of Messrs. Siemens Brothers Dynamo Works Limited. The Company is also making provision for a largely increased output in metal filament lamps, which will be sold henceforth by the Company under the distinctive trade name of "XCEL." This trade name will apply to all types of metal filament lamps manufactured by the Company, which include the following: Standard Vacuum Lamps; Half-Watt Lamps; Automobile and Battery Lamps (Vacuum and Gas-filled); Helical Filament Traction Lamps which have been designed specially to meet the requirements of Electric Tramways and Railways and for use in workshops and factories where lamps are subject to severe vibration.

As from 1st June, 1920, Messrs. Siemens Brothers & Co. Ltd. will conduct the business in Lamps and Supplies from the same addresses in London and the Provinces as hitherto, where, in addition to fittings and lighting supplies, attention will be given to inquiries regarding the whole of the material manufactured by the Company at its Woolwich Works, such as wires, cables, stannos wires, telephone and telegraph apparatus, fluid and dry cells, flashlamp and torch batteries, &c., &c.

The Company's Showrooms at 38–39, Upper Thames Street, London, E.C., have been redecorated and refitted, and all *bona fide* trade buyers are invited to call.

We are asked further to remind the Trade that the advice of the Illuminating Engineering Department of the Company is at the disposal of contractors to assist them in the development of any lighting schemes which they may have in hand.

ENGLISH ELECTRIC SUPPLIES, LTD.

PURCHASE OF BUSINESS OF THE BRITANNIA LAMP AND ACCESSORIES CO., LTD.

We are informed that English Electric Supplies, Ltd. (Brook House, 191 and 192, Tottenham Court Road, London, W.1) have purchased the business of The Britannia Lamp and Accessories Co. Ltd. (of Britannia House, 48, Milton Street, London, E.C.2). together with stocks, patents, trade marks, etc., and have the advantage of retaining the entire staff, both in London and the Branch Offices.

The business will be carried on on the same lines as formerly, and with the same products, with the addition of new electrical devices to be shortly placed upon the market.

All communications should be addressed to Brook House, 191 and 192, Tottenham Court Road, London, W.1 Britannia House being retained only as a warehouse, to which goods should be sent as formerly, unless contrary instructions are given.

It is stated that the removal of the office has given considerably increased warehouse accommodation.

All orders unexecuted and all obligations entered into by the Britannia Lamp and Accessories Co. Ltd. will be taken over by English Electric Supplies, Ltd.

ELECTRIC LAMPS FOR MOTOR-CAR HEADLIGHTS.

The importance of accurate manufacture, both as regards the construction of filament and complete exhaustion of the bulb, and also as regards standard dimensions, is of great importance in connection with lamps intended for motor-car headlights.

Our attention has been drawn to the "Lamp Bulb Guide for Car Lighting," issued by the British Thomson-Houston Co. Ltd., in which the various types of Mazda lamps are completely described and illustrated, and full particulars are given of voltage, watts and ampere rating. The booklet also contains an alphabetical list of British, European and American cars and motor-cycles in use in the United Kingdom, with information which enables the correct lamps to be selected for headlights, sidelights or tail lights of any one of the models shown. Copies of the handbook (No. 3-A) can be obtained on application to the British Thomson-Houston Co. Ltd., 677, Upper Thames Street, London, E.C.4.

B.T.H. EXTENSION AT CARDIFF.

The British Thomson-Houston Company have for many years dealt with a large volume of business through their Cardiff office. Since the war, however, this business has greatly increased, and we understand that the local office, although well organised and equipped has, owing to restricted storage accommodation, found it impossible to cope satisfactorily with the increased demand.

Accordingly the B.T.H. Co. have acquired, and now occupy, much larger premises at 7, Park Place, a few doors from the old address. The telephone number remains as before—Cardiff 4392. At the new office it will be possible to hold considerably larger stocks than heretofore, especially in the case of the many forms of lighting appliances and accessories.

This increased storage capacity will, it is hoped, ensure the immediate fulfilment of all orders for Mazda Vacuum and Half-Watt type lamps, B.T.H. Fittings and other standard lighting materials, and generally facilitate every phase of the Company's business in South Wales.

RONTGEN-RAY APPARATUS.

The *Sunic Record* for March contains some useful notes on diathermy apparatus, the Coolidge tube, and progress in radio-metallography and a discussion of the relative merits of the transformer and the induction coil. Attention is drawn to the Sunic fluorescent screens manufactured by Messrs. Watson & Sons, Ltd. (43, Parker Street, Kingsway, W.C.2), which beside being exceptionally sensitive to X-rays, are stated not to deteriorate with constant hard use in the same manner as platino-cyanide screens, besides having the advantage that there is no after-phosphorescence.

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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

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(Founded in London, 1909.)

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EDITORIAL.

The Artificial Lighting of Churches.

Early in the history of this Journal we published a series of articles dealing with the lighting of churches. Since that date considerable advances in methods of lighting have been rendered possible by the introduction of new lamps, such as those of the gas-filled type. It has also become necessary to guard against various defects, notably the exhibition of bright lights within the range of view of the congregation—a practice which is much more objectionable with modern illuminants than with the old lamps, candles, or flat-flame gas burners available in the past.

In his paper on this subject before the Illuminating Engineering Society (see pp. 141-157) Mr. John Darch rightly lays stress on the avoidance of glare as one of the chief considerations in church lighting. Other points mentioned include the provision of sufficient illumination to enable worshippers to read bibles or hymn-books or otherwise take part in the service, the need for separate appropriate lighting of the pulpit, and the desirability of adjustability in the lighting arrangements so that the illumination can be varied according to the nature of the service.

We are in full agreement with these principles. We are all aware how distracting it is for the congregation to be faced by bright unshaded lights at a low level when listening to the preacher, especially if these lights are in the vicinity of the pulpit. It is also evident that sufficient illumination must be provided for reading, and we should like to enter a strong plea for the abolition of the very small type used in pocket editions of the testament, prayer books, etc., which renders continuous reading a strain, even when the illumination is good, and especially in the case of young children. The importance of flexibility in the system of lighting is well recognised. In most churches the lights are turned down during the sermon, and the area to be lighted may vary much according to the nature of the service and the size of the congregation. Initial expenditure on a liberal provision of cocks and switches and sub-division of lighting is thus well repaid by economy in consumption of gas or electricity.

Having conceded these principles, which apply to the majority of places of worship in this country, it should be added that they require broad interpretation. In those cases where the congregation take little part in the service, which is conducted by the priest and his assistants, the amount of illumination needed throughout the church is naturally less, and in large cathedrals the provision of a uniform illumination sufficient for reading would present some difficulties. Some of the examples mentioned in the discussion also show how greatly methods of lighting are influenced by traditions and by special religious considerations. In churches of historic interest and distinction an excellent opportunity is often provided for the attainment of dignified and impressive lighting effects which add to the beauty of the interior, and in such cases the lighting fittings should be so designed as to be in harmony with the architectural features of the buildings. Viewed from this standpoint the use of unduly glaring lights is objectionable, as it spoils the view of the interior as a whole, and may give rise to harsh and inartistic shadow-effects. In some churches the light colour of the surroundings, and the positions of pillars, roof, arches, etc., lend themselves well to the use of concealed methods of lighting. It is sometimes advantageous to utilise the form of lighting for the purpose of accentuating the illumination on one part of the church (*e.g.*, the Altar and Choir), so that the attention of worshippers is naturally directed thereto. Cases also occur where local lighting may be applied to reveal some treasured monument or memorial.

We entirely endorse the claim made by Mr. Darch that in places of worship the lighting should be designed for the comfort of the congregation as carefully as in a place of education or entertainment. It should at least be possible to avoid instances of the misuse of light, such as the incorrect placing of lights in positions liable to inconvenience the eyesight of the congregation. We are aware that in many cases the small funds allotted make it difficult to secure really adequate lighting. We should, however, like to urge on authorities the very important part played by illumination in a place of worship, and the advisability of making grants for this purpose in circumstances where the local funds are insufficient.

The Brussels Congress of the Royal Institute of Public Health.

The Congress of the Royal Institute of Public Health, held in Brussels during May 19th—24th, was a pleasing reminder of the recuperative powers of Belgium, which is already playing its part as a centre for the international consideration of scientific problems, as in the days preceding the war. The writer has a keen recollection of the Congrès International des Maladies Professionelles held in Brussels in September, 1910, which proved to be the starting-point for investigations in several countries on industrial lighting in relation to health. It is interesting to recall that at the Congress of the Royal Institute of Public Health, which took place in Paris in May, 1913, consideration of illumination also played an important part in the proceedings of the newly-formed Section of Industrial Hygiene.

The present Congress was opened by the President, Lord Leverhulme, who gave an inspiring address in the presence of a distinguished gathering, which included H.M. the King of the Belgians, under whose patronage the Congress was held. Subsequently the new President, the Rt. Hon. Viscount Sandhurst, gave an admirable review of the scope and functions of the Congress. These addresses were followed by the presentation of a number of valuable papers, those in the section of industrial hygiene, presided over by Sir Thomas Oliver, being naturally of special interest to us. Several of these took up the threads of discussion initiated at the Paris Congress in 1913. The question of nystagmus, for example, which figured largely at the former Congress, was again taken up by Dr. Llewellyn, Dr. Stassen, and others, and the writer had again the pleasure of reading a paper on Industrial Lighting, from the standpoint of hygiene and safety. The opportunity was taken to point out the great need for international co-operation in dealing with both these two subjects. Already, on the occasion of the recent discussion before the Illuminating Engineering Society on Lighting Conditions in Mines, this was shown by the valuable statistics contributed by Dr. Stassen of Liège, whose researches afforded information on various points presenting difficulties to investigators in this country. Similarly in regard to industrial lighting, we have a problem which is broadly the same all over the world, the conditions of lighting required for the execution of specified industrial operations being substantially similar in all civilised countries.

It would therefore be of great assistance if experts in these countries could compare experiences and arrive at a common basis of action. Joint investigations would be particularly useful in securing statistical data on the conditions of lighting most suitable for the prevention of accidents, the relation between illumination and output, etc.

In the important matter of regulations on lighting in factories and workshops, as we have previously shown, international action would be most fruitful in promoting a common basis of working. It will be recalled that in Belgium a movement towards the appointment of a committee to study this problem was already on foot before the war, and the writer's recent conversations with authorities in that country lead to the hope that the matter will be taken up again in the near future, when the whole question of reconstruction is considered in detail.

A Visit to Czecho-Slovakia.

Few people in this country appreciate the size and industrial importance of the new Republic of Czecho-Slovakia, which before the war was known as Bohemia, Moravia and Slovakia. During the month of May a number of journalists, members of the British International Association of Journalists, visited the country at the invitation of the Czecho-Slovakian Government, the President of the Association, Sir Harry Brittain, forming one of the party.

Prague, which is now the capital of the Republic, besides being among the most picturesque and romantic of cities, is famous for the possession of one of the oldest universities in Europe. It is a hopeful augury for the newly-constituted Republic of Czecho-Slovakia that its citizens seem to have always been imbued with a proper appreciation of the value of good education. Even in the days of oppression, when they had little hope of aspiring to the higher positions in the State, these people sought learning. To-day, with brighter prospects, they should reap the reward of this tradition, and it is significant that their President, Professor Masaryk, is himself an educational expert who, during the early part of the war, occupied a distinguished position as a Professor at King's College, while several members of the present Government are men who rose from the ranks of the people and worked their way to the front by sheer ability and perseverance.

While at present faced by various economic and commercial difficulties, the industries of Czecho-Slovakia offer promise for the future. The present shortage of coal, wool and other raw materials hampers the development of the country, which, with proper encouragement and the extension of the necessary credit facilities, should ultimately fill an important industrial position. Among the commodities in which Czecho-Slovakia excels may be mentioned porcelain and glassware. Bohemian glassware was already famous throughout Europe before the war. Lighting experts are familiar with the illuminating glassware made at several works, which reveals great artistic skill and high craftsmanship. The output, however, is at present limited by lack of the necessary fuel, while the high price of this and other raw materials has increased the prices of articles to a figure about five times that prevailing in pre-war days. Of special interest to the writer was the development of artistically-designed chandeliers and lighting fittings in bronzed and gilded wood, the carving in some cases being remarkably fine.

During the visit the writer had conversations with many of the leading authorities, including the Minister of Welfare in charge of the Factory Department, who was greatly interested in the efforts being made in this country to promote a better knowledge of the benefits of good illumination, and was desirous of encouraging a similar movement in Czecho-Slovakia. This view was shared by the editors of several of the leading technical journals with whom the writer came in contact.

Our thanks are due to the Czecho-Slovakian Government for their hospitality and to Sir George Clerk, H.M. Minister in Czecho-Slovakia, for the great trouble he took to enable visitors to gain first-hand information on the industrial conditions of this newly-born Republic, to which we wish enduring prosperity and success.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE ARTIFICIAL LIGHTING OF CHURCHES.

(Proceedings at a Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m. on Tuesday, April 20th, 1920.)

A MEETING of the Society was held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.) at 8 p.m. on Tuesday, April 20th, the chair being taken by Lieut.-Col. F. A. CORTEZ LEIGH.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership announced at the last meeting on March 30th, who were formally declared members of the Society.*

It was mentioned that the Rt. Rev. A. F. WINNINGTON INGRAM, Lord Bishop of London, had been invited to preside, but had been prevented from doing so owing to absence from London, and the same applied to the Rt. Rev. BISHOP H. E. RYLE, of Westminster, who, however, in expressing regret at inability to attend, added that "the subject is of great public importance."

* ILLUM. ENG., April, 1920, p. 113.

The subject being of special interest to architects, general invitations to be present at the meeting had also been conveyed to the Royal Institute of British Architects, the Surveyors' Institution and the Society of Architects.

The CHAIRMAN then called upon Mr. JOHN DARCH to read his paper on **"The Artificial Lighting of Churches."**

In the ensuing discussion Mr. F. W. GOODENOUGH, Mr. T. E. RITCHIE, Lieut.-Col. F. A. CORTEZ LEIGH (Chairman), Mr. R. LANGTON COLE, F.R.I.B.A., Mr. J. S. DOW and Mr. L. GASTER took part. After Mr. DARCH had briefly replied to some of the points raised in the discussion, a vote of thanks to the author terminated the proceedings, after which the CHAIRMAN announced that the **Annual Meeting** would be held at 8 p.m. on **Tuesday, May 11th,** when the usual Report of the Council would be presented and an address given by Captain J. W. BARBER on **"Some Recent Developments in the Cinematograph."**

THE ARTIFICIAL LIGHTING OF CHURCHES.

By JOHN DARCH.

(Paper presented at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, April 20th, 1920.)

IT has been frequently stated that the church is one of the most difficult subjects for lighting. There can be little doubt of this, for the results that are to be found in the average church tell their own tale. But it is a tale of an amazing disregard of the fundamental principles of illumination, and it is to consider those principles and their application to church lighting that this paper is presented to this Society and thence to architects, church ministers and lighting engineers.

In the first place, the architect should realise that there is more in church lighting than in merely discussing "points" and selecting or designing fixtures, for so many leave the scheme of lighting, and consequently the results, entirely to a lighting engineer, who, in most cases, attempts no other method of lighting the church than by that of the chandelier and bracket, inherited from his forefathers. It is not for an architect to meddle with engineering matters, but it is certainly his duty to see that the artistic effect of his work is not ruined or the church rendered uncomfortable by unsuitable lighting.

There are, however, two very real difficulties that frequently rise up against the best of us. One is the hopeless inadequacy of church funds for the production of anything like a satisfactory result, and the other is an opinionated church committee or donor who feels that he who pays the piper can call for the tune. But when there is a free hand and sufficient money, what can be said of the architect or engineer who fails to respect the A B C of correct illumination?

Another question which may be said to add to the difficulty of church lighting is one of the old crusted sort, an obsolete tradition of the church, viz., that gloom is an aid to worship; this is still advocated by some architects and ecclesiologists. It is rather unfair to Milton that he should be credited with the advocacy of

THE "DIM RELIGIOUS LIGHT."

Let us deal with this question first. One of the advocates of religious gloom, writing in our own Journal,* tells us that "people who promote the introduction of modern light in the churches, totally forget the real object of places of worship." He goes on to say that "the masses who pray to their God must wander in the gloom between pier and pillar, or sit in the twilight in order to speak to God," and adds:—"Now when modern light is introduced, this fundamental fact is totally destroyed. We must retain the religious awe, the mysterious dark infinity."

An architect also writes on church lighting: "Mystery and imagination are the greatest aids to architectural effect."†

It is the architect and the ecclesiologist that are most prone to impose these adventitious conceptions upon the English church and not the clergyman or other

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* See ILLUM. ENG., Vol. II., p. 138.

† See ILLUM. ENG., Vol. II., p. 136.

professional exponents of Christianity. One London vicar bitterly complained to me that "fifty-seven haloed saints keep out the light of day" from his church.

We all love to think of the traditions and customs of the past, and it is right to preserve those that are healthy and profitable; but for the rest, let them remain in the story-books.

I do not forget that there are communities where mysticism and gloom form a part of their orthodox rites; I respect the sincerity of their convictions and should light their church accordingly.

But it is quite another thing when the Christian of the 20th century so misconceives the spirit of the New Testament as to advocate the retention of the mysticism and obscurity that characterised the several mystery religions that overran the early Roman Empire and that were afterwards introduced into the Christian Church. Those mystery religions must have been well known to the Founder of Christianity and in His many references to light, both literal and symbolical, He doubtless had them in His mind.

It was not until the 19th century that we possessed anything like an effective means of lighting a church, before which there existed nothing but "a light that counterfeits a gloom."

All this talk of mysticism, gloom and other emotional aids to Christianity is, therefore, futile. A healthy church must keep abreast of the times and be adaptable to the needs of the hour. There is no finality.

THE ATTRACTIONS OF GOOD LIGHTING.

Will good or bad lighting affect the attractiveness of a church?

Serious notes of alarm were sounded last year by the leading divines of all denominations because of their diminishing congregations. Some tried to remedy this by exhibiting flaming posters at the doors; others, emulating St. Philip Neri, introduced the oratorio and even the cinema into the church. You cannot cure a sick child with a rattle; entertainment may attract for a time, but it will never compensate for the miseries of bad lighting and for the boredom of a sermon that naturally becomes humdrum when one is unable to see the preacher. "Why," complained a clergyman to me, "should their zeal be directed towards hiding the preacher and dazzling the eyes of his flock?" And it is a very submissive flock; for though a few may complain, thousands endure it as though it were a just penance; but hundreds of thousands stay away.

Now the proprietors of regular places of amusement are wiser in their generation; they have discovered that good lighting and every comfort are necessary to success, and no lighting has been better studied or is more successful than that of the theatre. Now a church is not a theatre, nor ever should be, but the sagacity that has brought such prosperity to the theatre is equally necessary in the church.

It is said that a lady is well dressed when, although conscious that she looked nice, one fails to remember how she was dressed. Equally, a church is ideally lighted when the sources of light are not noticed, when one forgets that it is lighted while the eye wanders with pleasure over the attractions of the building or watches the preacher's expression with unconscious ease.

It is gratifying to know that there is a small but ever-growing number of churches where a rational system of illumination has been adopted, and I shall introduce some pictures of them presently.

A reverend gentleman writes, "When for the first time in your life you pass from a dark street into an auditorium flooded with mellow light and yet not a single glaring bulb is in sight to show you the source of it, the sensations you experience are very pleasing. If your eyes are a little weak, you find, as you walk into the room, that they are not instinctively half closing themselves for protection against the usual attack made upon them by a host of dazzling globes, for there is no such array to smite them; and finding that you can read in any corner as easily as in daylight, you say, 'This is a beautiful light,' while you realise that its soft and quiet efficiency makes it peculiarly adapted for church use."

THE PLEASURES AND PAINS OF LIGHT AND SIGHT.

Visibility is the sole *raison d'être* of the art of illumination and not a display of fixtures and lamps. Visibility is immediately impaired by the presence of those lamps in the field of vision, for the eye always adjusts itself to the brightest spot in view.

It is not a question of quantity of light, for the human eye can see with comfort under a daylight illumination of 8,000 foot-candles or a moonlight of one-hundredth of a foot-candle. But what it cannot do, without injury, is to see in both at the same time. It is therefore a question of contrast.

Professor Weber, ten years ago, fixed the limit of safe endurance of this contrast at 100 to 1, and an American committee has recently come to the same conclusion and added that indoor contrasts might go up to 200 to 1, but that contrasts were best at about 20 to 1.

With exposed lights, or even when they are in glass "shades," there may be a contrast of 10,000 to 1 or more. Unfortunately, in a church, the worshipper cannot turn, but has to sit and endure it; and with such violent contrasts before him he is unable to watch the preacher, he closes his eyes, he loses touch, his mind wanders and the sermon becomes an unconscious lullaby.

It has been said that the reason why gentlemen sleep more in church than ladies is because the ladies can dodge the lights with the brims of their hats.

Old-fashioned engineers excuse their work by saying that it is not everyone that suffers from the glare of exposed lights. Why should anyone suffer? But it is a fact that a large proportion do, and the reckless remainder will be consulting an oculist in due time. Those who still doubt should read the opinions of Mr. Parsons, Dr. Kerr and other leading oculists in the Society's Journal* and elsewhere.

The business man has found good lighting to be a paying investment, but church officials show no sign of grasping that fact. The greatest marvel, however, is that the ministers themselves do not appear to have realised that when they can be properly seen, as well as heard, they secure a double grip upon the attention and appreciation of their people. These are factors that should be the very breath of life to a successful ministry.

There is another point of physiological importance, viz.: the need for a sufficient light for easy reading. An insufficient light causes eyestrain to the adult and permanent injury to the young. This is aggravated by the small type commonly used in pocket editions, and made worse by being on very thin paper which sometimes allows the other pages to show through and confuses the print. A sufficient light emphasises the printed letters and clarifies the interspaces.

THE CLAIMS OF ARCHITECTURE.

Almost any church will demonstrate that the effort to produce a certain illumination on what is called the working plane—the pew—has been the only consideration and that all other interests of the church have had to take their chance.

Ruskin describes architecture as a source of "mental health, power and pleasure" and certainly the fabric of the church, with its impressiveness and its teaching, has ever been an influential factor in church life. It must, therefore, be visible; but its true effect can only be revealed in the light for which it was designed: consequently, in any other light it becomes an abortion.

We may see this in our City churches. When lit from below, the cornices, pilasters and ornaments have an upside down effect; but where they are lit from in front there is no effect at all, for the shadows are wanting. Sometimes, we find a tangle of repeated shadows and high lights that reduces the whole to an architectural puzzle. It is lamentable when the effect of a beautiful work is thoughtlessly ruined by those who profess no knowledge of architecture and no sympathy with its poetry and sentiment, but it is inconceivable that an architect should be content to see his own work so burlesqued.

If we study the daylighting of the old Gothic churches we shall see that the nave is lit principally from the clerestory windows and the large west window

* See ILLUM. ENG., Vols. III and X.

FIG. 1.—St. Petronio, Bologna, showing natural effect of Overhead Daylighting.

behind (Fig. 1). Architects in our day are but copyists of the work of men of bygone ages, who thought for themselves and who were the soul of a living art. If, therefore, we adopt their architecture, let us adopt their principles of lighting it, for the meaning of architecture is in the light that reveals it.

Gothic architecture is native to dull northern climes, hence its aspiring lines and its mouldings (deeply cut to emphasize and shadow those lines) are better suited to a well-diffused light. So let the evening discover by artificial light what the morning has demonstrated by natural light.

Classic Renaissance is represented by a great many churches in London. The interiors of their prototypes in the sunny south were open courts and were lighted from above; so also were their later development, the Basilicas. Here well-marked shadows impart the beauty and nobility which characterise this style; and it is from a top light only that it should be lit.

Several architects have expressed their opinion that Gothic churches look best in a subdued light. Diffused, it should be, but not subdued. The north transept of Westminster Abbey looks none the worse for being in broad daylight; and because some of our old interiors were kept in semi-darkness that is no reason why its modern imitation must be so. When we copy ancient architecture we should realise its *spirit* and avoid its faults. Although mediæval times were slow, its art was progressive; and if high-power lighting had been available in those days those old architects would have been the first to utilise it and they would have boldly modified their buildings to suit the necessary lighting devices.

Such interiors as St. Paul's Cathedral and the Cathedrals of York, Winchester and others are of such sublime proportions and beauty that the pettyfogging lights from chandeliers and standards are an insult to the building. Large buildings need high power lights which, after all, are economical.

THE ILLUMINATION OF FLAT DECORATION.

1. Works of Art in mural decoration may be of great value and importance either as mosaics, frescoes or oil paintings. A church should not be treated as a picture gallery, but there may be reasons why an important work should be made easily visible. If its proper illumination is not obtained by the general lighting, local lighting may be necessary, and the principles which govern the lighting of picture galleries should be considered.

In any case valuable works of art should be lit (*a*) sufficiently, and the intensity will depend upon the depth of colour; (*b*) uniformly; (*c*) so as to avoid gloss, and (*d*) with as white a light as can be obtained. The half-watt lamp or the super-heated gas mantle are a good approach to white, but if, with the electric light, it is necessary to bring out the greens and blues the addition of a small mercury vapour lamp might be better than nothing.

2. Inexpensive Decoration, such as a plain colour scheme, perhaps in panels with stencil ornament, may be intended to produce nothing more than an impression of comfort and pleasure, but even that demands some thought, for in broad masses of colour there is often a small margin between relish and nausea and that difference is easily

made possible in lighting. This brings us to the question of

THE IMPORTANCE OF DIFFUSE REFLECTION.

The coefficient of reflection (K) in walls and ceilings is a factor of the utmost importance and will usually make all the difference between success and failure. In a favourable case of direct lighting with say $K = \cdot 6$ it might possibly add 50% to an initial illumination which need not be great to be satisfactory. But with old oak or other dark walls and ceilings, with K near zero, one not only loses the increase from reflection but it needs 5 or 6 times the illuminating power to get anything like a good effect, and this has the drawback of putting any white or light spots into painful contrast.

A church with a light interior, particularly the ceilings and upper walls, will cost much less to illuminate and be more satisfactory than a dark interior. Such an interior should not be uniformly white but have quiet varitoned surfaces which, with any mural tablets, etc., should still be light enough for economy and yet more pleasing.

DECORATIVE LIGHTING

is a spectacular form of lighting in which small lamps are usually arranged to form patterns and lines round the arches and along other main features of the building. Its luminous lines dominate the view and reduce everything else to comparitive unimportance. It is not illumination but *illuminations*, reminding one of an Earl's Court Exhibition. There is such a line of lamps round the dome of St. Paul's Cathedral. The arches of St. Mary's, Redcliffe, Bristol, have been so treated, and there are others. I also remember a dispute in which an American bishop wanted so to line up the interior of one of the largest cathedrals in America.

LIGHTING INTERIORS FROM OUTSIDE.

Artificial illumination from the exterior of the clerestory windows has been tried at Montreal Cathedral, and it is said that that alone enabled one to read in any part of the church. I have always thought that high-power lamps might be successfully employed at clerestory windows and skylights or in what is called deck lighting, because from those points we should obtain the most natural distribution.

STAINED GLASS WINDOW ILLUMINATION

has been tried with success. We have all noticed the mysterious blackness of church windows at night and felt their cold incongruity with the cheerful interior. Should one of them be of worthy stained glass, it may be illuminated by small units of electricity or gas through a thoroughly diffusing medium. Uniformity is essential, but the surface luminosity should not greatly exceed the surface brightness of the walls.

FESTIVAL AND SYMBOLIC LIGHTING,

used in churches of high ritual, is frequently spoken of as complicating the question of church lighting; but whatever complication there may be, it is in the installation rather than in the principle of illumination; for the normal lighting always exists as a basis, and festival or other lighting should be supplemental and separate. It frequently happens that it is simply a large increase in the general illumination, and when, for example at Easter, the lights would be lowered for a short time, the whole would blaze forth at a given point in the liturgy, to symbolise the joy of the Resurrection. Or the extra lighting may take the more spectacular form of emblematical devices usually formed by small electric lamps, but in Vol. II. of the Society's Journal there are pictures of gorgeous displays in acetylene.

My previous condemnation of spectacular lighting as a permanency does not apply to that class of lighting in church festivals, because it is of short duration and forms part of a religious ceremonial.

PRACTICAL SUGGESTIONS.

In submitting suggestions for the solution of the problems of church lighting I wish to make it clear:

That I have no intention of discussing the purely engineering technicalities of the installation; and

That I have no preferences for electricity or gas or for any particular mode or system of lighting, least of all for any particular fitment or device, *so long as it all conforms to the following simple rules.*

RULES FOR CHURCH LIGHTING.

Rule 1. *The lamps to be so placed that they do not occupy the field of vision.*

Maxims to this effect are so frequently quoted and so little observed that I feel some diffidence in bringing forward this old saw. It is amazing that firms of repute can publish articles and photographs exhibiting low-placed and front lighting as good examples of modern lighting.

This rule is a *sine quâ non* and must be strictly observed. It is not sufficient that the bare lamps be covered with prismatic or even opal glass; nor is it sufficient to raise pendants or shift brackets unless they can be taken out of the field of vision.

Rule 2. *The illumination should be sufficient and so arranged that the objects shall appeal readily and truthfully to the eye and so that perception may become a pleasure.*

The illumination should extend to all parts of the church, leaving no overhead and other masses of obscurity. In many churches, particularly those of Classic Renaissance, there is no valid objection to the ceiling being in stronger illumination. By careful choice of positions of lights, and by taking the fullest advantage of the reflective power of walls, etc., pleasing contrasts may be obtained and violent contrasts avoided. This rule implies that the light should fall as nearly as possible in the natural direction. It also implies a well-diffused light; not shadowless, but with the variable gradations that one sees in a good daylight photograph.

Rule 3. *The illumination in the pews should be sufficient in intensity and convenient in direction.*

The amount of illumination should not be less than 1½ foot-candles and need not be more than 2½ foot-candles, but in the choir stalls it should be 2 to 3 foot-candles. The direction of the light is important, as many persons in a congregation may be seen stooping or twisting one way or another in their efforts to get an easy reading light on their books. It should fall downwards and forwards from behind. There should also be some diffusion, for to see the black hard shadow of one's fingers on the book is suggestive of street lamps.

Rule 4. *The colour of the light should approach white as nearly as may be obtainable.*

One engineer exclaimed, "We don't want daylight at night," and another thought that "yellow light was more cosy." This opinion, which is widely held amongst engineers, is sheer conservatism. It was in the same way that our forefathers clung to the ruddy pine log, then to the smoky oil lamp and the guttering candle, and on the introduction of gas lighting it was thought to be tempting Providence to use it. So now, some of us, in our turn, hang on to the tail of progress and to the inefficient yellow light of our boyhood days. Progress in light production has always been in the direction of a purer light—so much better for us whose constitution is adapted to daylight. We must be in the forefront or go to bed at sunset as our forefathers did.

Rule 5. *Separate local lighting should be provided for the pulpit and wherever the general lighting is insufficient.*

Pulpit lighting needs careful treatment, and will be dealt with presently. Local lighting may also be required at the reading-desk, and certainly for the organist. If the general lighting is not sufficient for the hymn boards, clock dial, wall notices, etc., local concealed lighting may be desirable. In Catholic churches the stations of the Cross or other representations may need special illumination, but in other churches no attempt should be made to specially illuminate pictures or monuments not required in the service. "Notices" of importance at the doors are usually passed unnoticed for want of sufficient light. These should be illuminated with screened lights.

Rule 6. *Provision should be made to subdue the general illumination during the sermon or when required.*

This practice is observed in many churches, but is not universal. It is, however, desirable, as it centralises attention on the preacher and is a quiet relief to the eyes when nothing else requires to be looked at, to say nothing of the saving

in the quarterly bill. It should not approximate to darkness, but may be brought down to about one-sixth of full illumination. If the lights are exposed to the preacher it would be better to dim all the lights, or, in suitable cases, to employ small movable screens that can be controlled like a louvre ventilator. But where the lights are not within sight of either preacher or congregation it might be better to extinguish the majority of the lights, leaving a few running full under the control of a separate electric switch or gas valve.

THE AVAILABLE SOURCES OF LIGHT.

Electricity or Gas. The choice of electricity or gas is almost immaterial to the actual results. Electricity is the more elastic in its possibilities of distribution. Gas claims other advantages. Either is adaptable to the schemes I suggest.

Acetylene is usually the only effective means of illumination for country churches. It is used in the form of an open flame giving about 15 candlepower from a small half-foot burner and an intrinsic brilliancy of about 70 candlepower per square inch. Such brilliancy when placed in the field of vision would create a great deal too much glare to be tolerable. In most cases, however, acetylene would adapt itself to the principles and methods I am advocating.

Oil Lamps, etc. Hundreds of churches and chapels have to be content with self-contained lamps, of which some very efficient types, having luminous flames or incandescent mantles, may be had The more efficient they are as light producers, when hung low, the more objectionable the glare from them The simple method, B, that I am about to describe would work wonders in comfort and visibility.

Electric Vapour Lamps have not yet found a place in practical lighting, but the Moore tube when filled with CO_2 gives a beautiful soft white light and has been used at least in one small chapel.* The mercury vapour lamp is much more economical, but its greenish-blue colour would militate against its use excepting in combination with ordinary lamps, as already suggested.

* See ILLUM. ENG., Vol. III., p. 669.

THE CHOICE OF METHODS.

It will be convenient to divide the methods of lighting into six classes, four of which are direct lighting and two indirect. Of these the first is the only one that is ruled out; either of the remaining five are available for choice.

The bewildering variety of arrangement, character and detail to be found in our churches render it useless to prescribe any one of these methods for any particular class of building. Before adopting either, or any combination, a careful study should be made of the church in question—its plan, its roof, its architectural details, its seating arrangements and the colour of its walls and ceiling, all of which will profoundly affect the problem of its successful illumination.

Method A—Exposed low-level lighting. This is the common, but no less barbarous, method of placing brilliant bare or glass-covered lights before the eyes of helpless worshippers. It is to point out a more beneficent way that I am giving this paper. Fig. 2 is of a popular church with modern lighting, and shows that the preacher in the pulpit (in front of the organ) cannot be seen apart from the four staring lights around him; one, worst of all, being below him. There are other lights in full view.

Method B—Shaded low-level lighting. This consists of a method of shading only, and can be applied to existing installations to ameliorate or cure the evils I have just referred to.

In my article on "The Art of Shading," appearing in Vol. II., pp. 83 and 173, of the Society's Journal, I have more fully discussed the principles involved, and they will be found applicable to this method of church lighting. The shades should be either opaque or nearly so, *i.e.*, not exceeding a surface brightness of ·05 candlepower per square inch or 7 candlepower per square foot.

In some cases simple flat screens, in others half-round, quite small, would be sufficient, so long as it clears the lights as in Fig. 3, and there would be cases where proper ring shades would be desirable. There is no reason why the

FIG. 2.—Showing Low Front Lighting and four lights around the High Pulpit.

glassware itself should not become real shades. The effect in comfort and increased visibility would well repay the cost.

FIG. 3.—Half Round Shades.

An interesting example of low-level shaded lighting was designed by Mr. Cravath, which I have put into perspective form in Fig. 4. It is a box of wood or other material, open at the bottom. I am afraid that it would be considered ugly, but it serves its purpose perfectly, and I would far rather see it in use than the common type of pendant.

Fig. 5 is a more convenient modification. Both are suitable for gas or electricity.

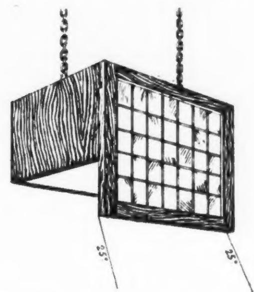


FIG. 4.—Cravath's Box Shade for Low Level Lighting, with Dense Glass at back.

Method C—Overhead direct lighting from ceiling or roof. It may be concentrated in a few units or distributed over many points.

In overhead lighting we take a leaf out of the text book of Nature. Such lighting illumines the whole interior more naturally and affords good visibility and freedom from glare. It is particularly appropriate to churches with panelled and other ceilings, but the character of any installation would be governed by the design of the ceiling or roof.

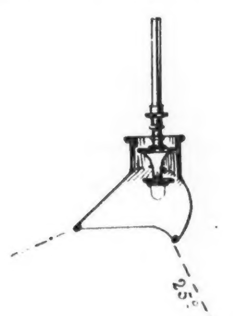


FIG. 5.—Shade for Low Level Lighting.

One of the best devices for overhead gas lighting is the ventilating sunburner. The older type of open flame burner has already been in use in a number of churches and was found costly, but the modern types which employ clusters of small, and therefore durable, mantles, give as much as from 650 to 1,000 candle-power for only 20 cubic feet of gas per

hour. In the north, many Gothic as well as other styles of churches are using them. Arrangements can be made for lowering the burners and access is facilitated when there is a roof space over the ceiling. The half-watt electric lamp could be economically employed in the same way.

It is important in any kind of overhead lighting that the lights do not come within the angle of view. The eyebrow angle is 25° to 30°, but that angle might in these cases be extended to 35° or the foremost unit might be shielded so as to preserve that angle. See Fig. 6.

Method D—Concealed direct lighting, in which lamps are placed behind arches, window reveals, columns, etc., and are not visible from the ordinary point of view.

This method will be available in most Gothic churches. The chancel calls most loudly for concealed lighting with its improved visibility and charming effects. I did one as far back as 23 years ago, but concealed lighting may now be found in the chancels of many churches.

But the whole church may be lit in the same way. Take, for example, St. Dunstan's, Acton (Fig. 7). Reflectors with four 60-watt lamps are placed on the east side of the arches to light the nave and aisles, giving from 1 to 2 foot-candles in the pews. The chancel has a higher illumination. There is a lack of diffusion, due to the dark walls and to the darkness overhead, but the general effect and the visibility are very pleasing.

To illustrate the improved effect of lighting from above and of lighter walls

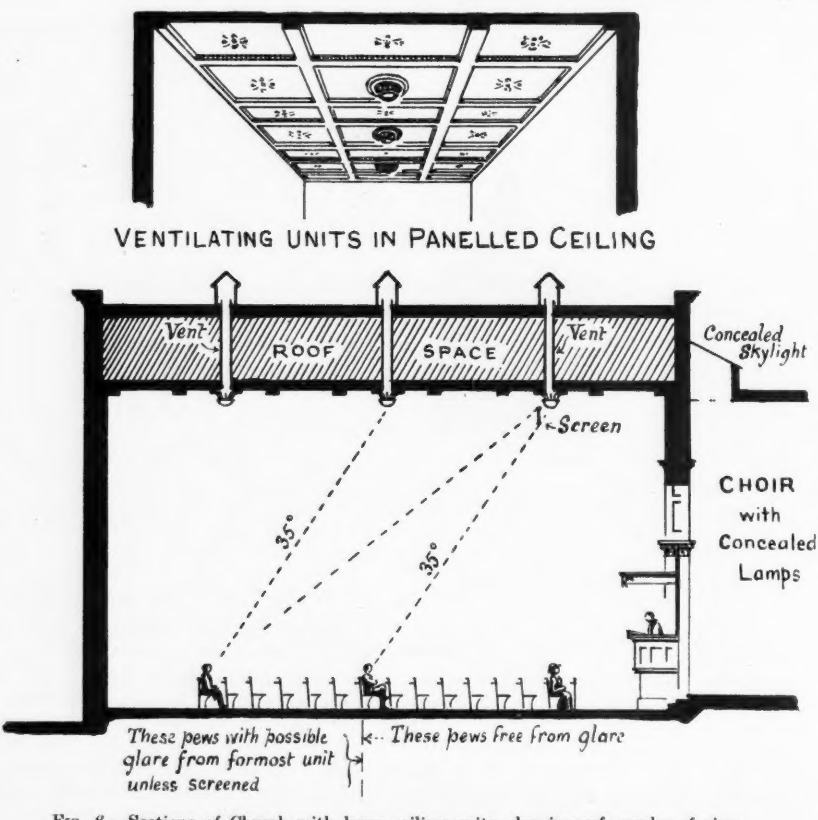


FIG. 6.—Sections of Church with large ceiling units, showing safe angles of view.

FIG. 7.—St. Dunstan's, Acton. Concealed Direct Lighting.

FIG. 8.—St. Anne's, Edgehill, Liverpool. Concealed Direct Lighting.

I submit a photo of St. Anne's, Edgehill, Liverpool (Fig. 8). In this the lamps are concealed behind the wall posts in the upper nave and the illumination is perfect throughout.

The fine old choir of the historic church of St. Mary's, Warwick, deserves to be properly lit, and the beautiful rib groined roof, though in a subdued light, crowns the charming view (Fig. 9).

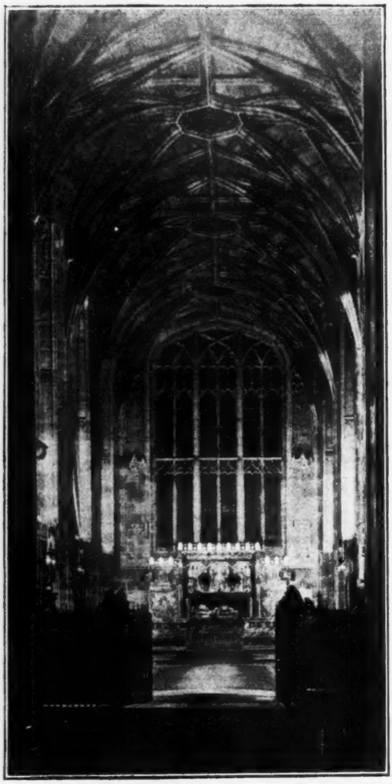


FIG. 9.—St. Mary's, Warwick. Concealed Lighting to Choir.

We have many old churches with open roof trusses and low tie beams behind which lights may be easily concealed. The sketch (Fig. 10) shows this with incandescent gas burners and prismatic glass reflectors, but acetylene or electric light could be as easily adopted. This arrangement has already been adopted with success.

Method E—Indirect lighting from opaque bowls, containing concealed lamps and reflectors. These are generally suspended, but may be placed on brackets or high standards. Indirect lighting is best suited to churches with light coloured domes, vaulting or other expansive ceilings, and light upper walls. As the reflective power of these surfaces is an essential factor in the illumination they should not be allowed to get too dirty. Its characteristic is its natural overhead illumination—and its advantages are its agreeable diffusion, its power of softening, without destroying, the shadows; and particularly the high visual efficiency that is possible with it. It is said to be less efficient per lumens generated than direct lighting, but the above-named advantages, combined with the possibility of using powerful and economic lighting units, should compensate for the loss in absorption. I have, however, seen it used where I think direct overhead lighting would have been better and *vice versa*, which goes to show the importance of unbiased advice.

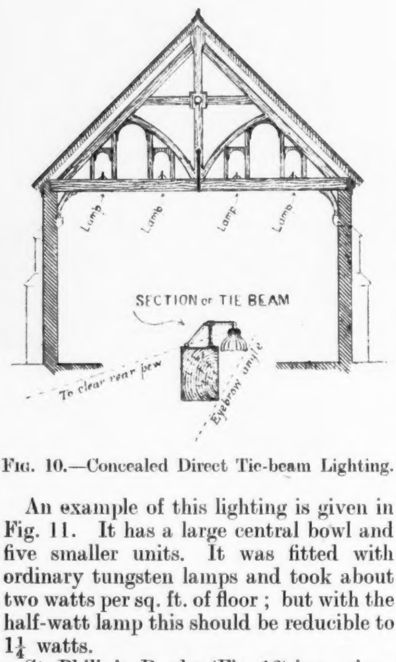


FIG. 10.—Concealed Direct Tie-beam Lighting.

An example of this lighting is given in Fig. 11. It has a large central bowl and five smaller units. It was fitted with ordinary tungsten lamps and took about two watts per sq. ft. of floor; but with the half-watt lamp this should be reducible to $1\frac{1}{4}$ watts.

St. Philip's, Rugby (Fig. 12) is a unique type of church with plain walls and tunnel ceiling. One quails before its bald uniformity, but this fault is in the church, and not in the lighting, which is a success. If the walls below the moulding had been made darker and varied by lines or panels, it might have been all that could be desired.

This method is admirably suited to domes, for distance does not kill light and

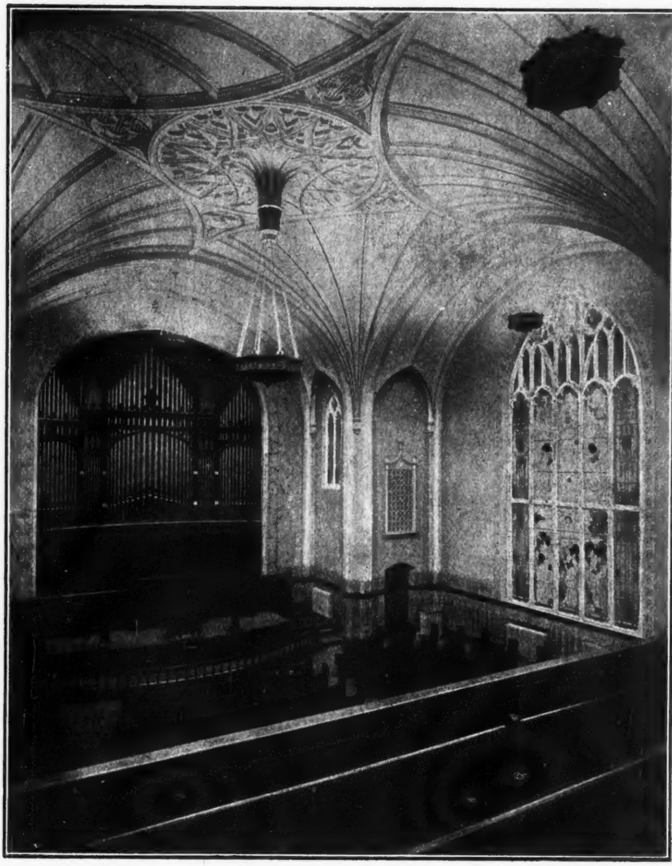


FIG. 11.—Eberhardt Memorial Church, U.S. Indirect Lighting from Bowls (from *Modern Illuminants and Illuminating Engineering*).

a reflecting enclosure conserves it. Fig. 13 is a successful example in Chicago. The central bowl is 90 in. dia. with twelve 400-watt Mazda lamps with reflectors. The total wattage per sq. ft. was 1·45, but with half-watt lamps it should be reducible to 1 watt. There are some beautiful church domes in London that would respond magnificently to this method, but that are now suffering from miserably inadequate and offensive pendants.

Method F—Indirect lighting from concealed positions can be used only in churches whose architectural features are adapted to it, such as suitable cornices, clerestory and other high window sills, the tops of screens, and columns, etc. A possible objection would be the risk of great inequality of illumination, but this may be corrected by combining methods E or D with it.

In considering the various methods above described there is, of course, no reason, should the case demand it, why combinations of the methods should not be adopted, providing that unity of design in the lighting is not impaired.

PULPIT LIGHTING

must be governed by the following rules. Firstly: In the interests of the congregation:—

(*a*) Neither the lamps nor the inside of the reflectors to be exposed to view.

(*b*) The preacher's face to be naturally illumined and naturally shadowed so that every expression is observable.

(*c*) The reflectors to be well clear of the preacher's head but not too far for economy of light.

Secondly: In the interest of the preacher:—

(*d*) The light to be outside his angle of vision.

(*e*) The paper gloss angle to be avoided.

(*f*) The desk illumination to be about four foot-candles.

(*g*) The switch to be in the pulpit. A second switch might be desirable to vary the intensity.

To illustrate these rules, let us take Fig. 14. Draw EL from the preacher's eyebrow at an angle of 28° or 30° from the vertical. Place the lamp inside this line at a height of say 4 feet above the preacher's head. Draw LR, representing the incident ray from the lamp to the centre of the desk and from R the reflected ray at the corresponding angle. If this ray does not clear the preacher's eyes the angle of the desk should be adjusted or the lamp shifted.

The interior of the reflectors should be white (not silvered). The exterior will be the subject of design dependent upon the means of fixing; otherwise they should be unobtrusive and not larger than necessary.

I have seen long trough reflectors, but it is better to have two separate reflectors set about 5 feet apart, each containing two smaller lamps rather than one larger one, and that on the preacher's left preferably a little the stronger. The reflectors must not converge to the preacher, but the inner ends should slope. If the pews extend laterally on either side of the pulpit, side wings W may be required.

Many churches have sounding boards or canopies over the pulpit; it is then a very simple matter to put the lamps behind the valance. Fig. 14 shows this arrangement respectively for gas and electricity.

Orchestra tubes and the like, although used, are not suitable for pulpit use, as

FIG. 12.—St. Philip's, Rugby. Indirect Lighting.

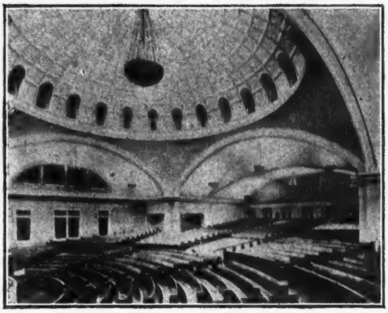


FIG. 13.—Church of Christ (Scientist), Chicago. Indirect Lighting from Bowls.

they leave the preacher's face in darkness; but they are all right on reading desks because the church is fully lighted during lessons. The same remarks will apply to shades of the type shown in Fig. 15, the insides of which must not be seen.

PORCH LIGHTING.

Porches, with their unexpected steps and mats, are frequently a source of anxiety to old people and a danger to all, and need careful lighting.

Don't put a central pendant or other light that can be seen as you approach.

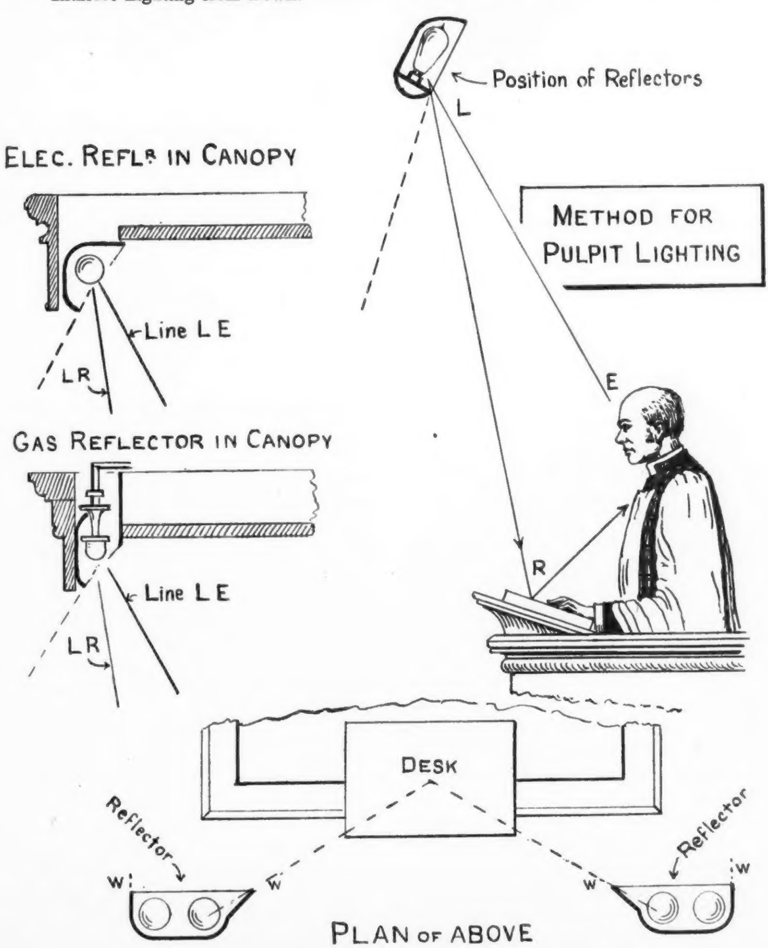


FIG. 14.—Pulpit Lighting, with and without Canopies.

Don't use a modern antique lantern that casts broad bars of shadow to increase confusion. Any light may be used, with or without glass, if it can be concealed by the arches or is otherwise screened. Screening and concealing should, and can, be done without prejudice to the illumination. The character of the porch must be taken into consideration.

FIG. 15.—Reading Desk Shade.

I will close my paper with a few remarks on

THE LOGIC OF FIXTURES.

In a short paper which I read before this Society in 1915, " On the Principles of Design in Lighting Fixtures," I discussed the motives for their employment and the principles of Art in their design. I now wish to add a word on their application to church use.

The basic principle of Art in designing a fixture is that it should serve its purpose and its place. Make it as good and beautiful as you can, but it must, first of all, be rational and efficient and not exceed the limits of its usefulness. The illumination should govern the fixture and not the fixture the illumination; and yet it commonly happens that the church fixture is considered first and the lamps added as they will admit; while the illumination takes its chance. This is abundantly manifest. Take St. Paul's Cathedral: consider the enormous sums that have been spent on the fixtures, and then look at the depressing gloom called lighting.

Let us suppose that in working out a lighting scheme we find that some sort of a fixture becomes necessary. It is for the engineer to design that which will most effectually achieve the object in view—the illumination: it is then for the artist to mould the device into a thing of beauty. He need not essentially alter its form, but he should put grace and elegance into it, and certainly he should not mask its identity with an incongruous incrustation to represent something else.

Emerson has defined beauty of form as " that which has no superfluous parts and which exactly fulfils its purpose." Beauty in the " human form divine," for example, arises entirely from its essential working parts; anything added would be superfluous and therefore ugly.

If we build a church after a 13th century model, we must not forget that the beautiful structures of those days, with their charming perspectives, graceful arcades and rich detail, were complete without the obtrusive lighting fixture. Nor was there any provision or place made for their reception and so, now, they have to be foisted upon walls and columns that do not take kindly to their presence.

The fact that wax candles were the only church illuminants permitted in those days may justify such monstrosities as the coronas of Hildesheim, Treves and others; but it does not follow that we should go on making candle coronas when our means of lighting is so entirely different.

There are those who think that a church is incomplete without a chandelier; there are also those who think that a man is incomplete without a pipe in his mouth. I am not against fixtures where they are necessary, but my point is that in dealing with ancient buildings, or their modern copies, we should conserve their spirit better by lighting them on the rational principles I have laid down, and if that lighting can be accomplished better without fixtures at all, then their presence is an unjustifiable infliction.

THE ARGUMENT IN A NUTSHELL.

The conclusion of the whole matter is that the present methods of lighting a church are bad and as out of date as the use of candles and gas flames for which they were designed. They are offensive and injurious to the eyes, they defeat their own object by reducing visibility and certainly help to empty the churches.

But now that sound principles of illumination have been established, those principles should govern every installation; the modern illuminant, which has come to stay, should be handled in a manner suitable to its character, and the church made as attractive and comfortable as a theatre or a good public library with pleasing lighting and easy visibility, and efficient heating and ventilation. I have given some simple rules for church lighting which should be strictly observed in every installation, and a choice of several excellent and economical methods of lighting that should meet every need and give a new pleasure to church-going.

I wish to acknowledge the courtesy of the British Thomson-Houston Company in lending several lantern slides and photographs, Figs. 7, 8, 9 and 12, of their work for reproduction.

DISCUSSION.

Mr. F. W. Goodenough expressed his thanks for the comprehensive paper read by Mr. Darch, from whom he said they always looked for something individual and original. He had the courage of his opinions, and liked other people to express theirs. He (Mr. Goodenough) did not go all the way with him in his anxiety to illuminate a church as completely as he would illuminate a theatre or place of amusement. He (the author) was keen upon ample lighting in a place of worship, and threw scorn upon the dim religious light.

Although he (Mr. Goodenough) was interested in the supply of light, he must say the mysterious gloom of some churches had a great attraction for him. He would not like the Cathedral at Rouen, or the Church of St. Ouen in the same city, as brilliantly illuminated as some of the churches they had seen on the screen. He thought the religion that was practised in a place of worship had to be taken into account. When dealing with the lighting of churches one was not dealing merely with the lighting of Protestant or Christian churches, but places of worship of all descriptions, and he thought some religions would prefer the dim religious light to the brilliant illumination Mr. Darch advocated. He would apparently do away with stained glass windows because they kept out the daylight. He (Mr. Goodenough) could not agree with him there. He would be very sorry to do away with the east window of York Minster or the south window of Sherborne Abbey to get more daylight in.

He did not think the lighting up of a church had anything to do with the size of the congregation. If the preacher were a dull one a brilliant light would not fill the church, just as it was not the good light of the theatre that filled the theatre, but the good actors and good play. The theatres were filled before they had the present lighting. For one person kept away from church by the miseries of bad lighting, thousands were kept away by the boredom of bad sermons. The author said the reason that gentlemen slept more in church than ladies was that the latter dodged the light with the brims of their hats. He thought the ladies kept awake because they had each other's hats to study. One of the greatest troubles in connection with churches was want of ventilation rather than want of lighting. He thought it was the bad ventilation that made churches such sleepy places as well as the bad product from the pulpit.

Apart from the question of principle whether a church should necessarily be lighted on the same lines as a place of amusement, he had no criticism to bring against the paper. The author had dealt with the subject in a most efficient way, and had given most practical suggestions and examples of good work that had been done, and those concerned with the lighting of churches would find the paper of great value and interest. He was sure the author would take his small criticisms in the spirit in which they were made.

Mr. T. E. RITCHIE also expressed appreciation of Mr. Darch's paper. The subject was one that deserved fuller consideration than it had received in the past. One point, which he thought deserved emphasis, was that in most, if not all churches, two distinct conditions of lighting were required. At one period of the service it was necessary to be able to read easily, but during other parts this was not the case, and one did not need nearly so much light. In most of the examples shown there did not seem to have been sufficient provision made for the desired range and variation in lighting.

He agreed with Mr. Goodenough that, at any rate during some periods of the service, the " dim religious light " was a potent factor in the appeal of the service to worshippers. Roof lighting, of which the author had shown a number of examples, was of great value. The lighting of any church should be studied in relation to its appearance by daylight, and he thought that, with natural lighting, there would be found to be quite as great a variation in intensity as by artificial light. At the same time, one should bear in mind the aims of the designer of the church who, presumably, arranged the windows so as to give the conditions of lighting which he considered the church to need. The paper should be the means of stimulating thought, and would, he hoped, lead to the artificial lighting of churches being more carefully studied.

THE CHAIRMAN (Lt.-Col. Cortez Leigh) regretted he had to leave shortly, but before going he wished to take this opportunity of thanking Mr. Darch personally for his very interesting paper. He did not know that the fact of people going to sleep during the sermon was altogether due to the lighting, but thought it might sometimes be attributed to an inferior preacher. He understood that there were apologies from some high dignitaries of the Church who had intended to be present, and he was sorry they had been prevented from attending. It would have been helpful to hear their views on the subject as the Clergy were so largely interested and had experience of all sorts of Churches and no doubt hear criticisms from their parishioners. He agreed with Mr. Goodenough that it was a debatable point as to whether a Church should be lit as described by Mr. Darch, or whether the " dim religious light " was sufficient or even preferable. It was largely a matter of taste and of the habits of the country; it would no doubt have been observed that the beautiful lighting of the American Churches Mr. Darch had shown rather resembled a theatre. They had seen the effects of the different forms of lighting reproduced, and from that point alone the Author had rendered a very great service. The Paper had been well thought out and must have required much trouble and patience to produce.

Mr. W. E. BUSH (B.T.H. Company) was pleased to see that the Author advocated concealed lighting, or lighting from concealed sources. Sometimes it was considered that that system of lighting was too costly to install—very often more points were required, and consequently more fitments—but, of course, that did not apply where the church had plenty of funds, and if they did not have concealed lighting they would probably have very ornate brass fittings. If they had the choice of the two, they should be urged to put in concealed lighting. He agreed with the Author that committees were very difficult people to deal with on this question. They did not, as a rule, know anything about engineering, and they simply settled the question of their lighting by how pretty the drawing of a fitting might be. A highly coloured drawing usually appealed to them a lot more than the reflecting power of the fitting or the lamps that were to be used. But these people invariably settled the thing, and as they paid the piper they often called the tune.

Mr. Darch taxed one or two firms with publishing pictures of church installations which had direct lighting, or diffusing bowl fittings. If a church committee could not afford to install concealed lighting, why not give them the next best thing? Mr. Bush maintained that it was possible to install diffusing bowls in a church and illuminate it quite well. He showed one or two slides of churches illuminated in that manner, the first

FIG. 1.—St. Luke's, Swindon. Prismatic Bowl Fittings and Mazda Lamps.

FIG. 2.—Congregational Church, Rugby. Diffusing Bowl Fittings with Prismatic Glass over Reflectors and Mazda Lamps.

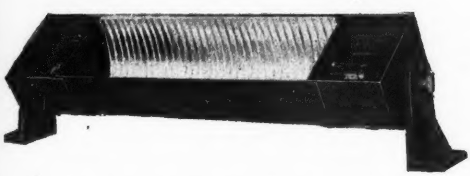


FIG. 3.—Mirolux Trough Reflector.

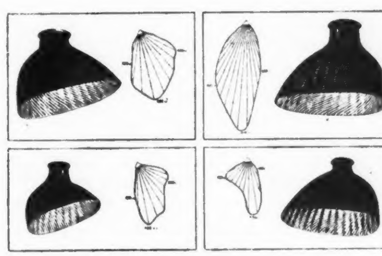


FIG. 4.—X-Ray Angle Type Reflectors.

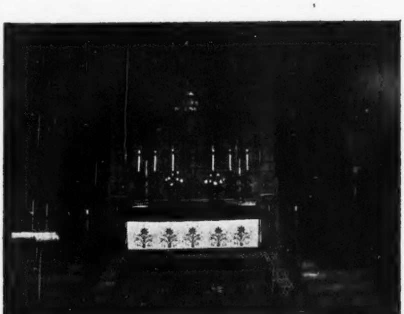


FIG. 5.—St. Andrew's, Plaistow. Sanctuary. Original Gas Lighting.

FIG. 6.—St. Andrew's, Plaistow. Sanctuary. Lighting from concealed Mirolux Troughs.

being St. Luke's Church, Swindon (Fig. 1). Provided the bowls were sufficiently high—say 15 ft.—he did not see any objection to their use. There was very little glare, the lighting was very even, and, if he remembered correctly, the intensity was about 3½ foot-candles. The upper part of the church was by no means dark. Another picture was of the Congregational Church at Rugby (Fig. 2). In that also diffusing fittings were used—opal bowls with prismatic reflectors. The Author had shown a number of pictures of churches, including St. Anne's Church, Liverpool, and the Church of the Sacred Heart, Donnybrook, and several others in which the installations were engineered by his (Mr. Bush's) Company. They found such photographs very powerful weapons and they often influenced church committees and authorities to adopt lighting from concealed sources.

He thought it a pity that the Author had not given his opinion as to types of fitments which he recommended. The Author had refrained from giving engineering data, or suggestions for reflectors for concealed lighting, but gave one or two crude examples, if he might use the expression, of how to hide naked lamps. It would have been interesting if he had given some particulars as to what he considered ideal lighting units for concealed lighting. Mr. Bush exhibited slides showing the type of reflector used at St. Anne's, Liverpool, Donnybrook, and several of the other churches that had been shown (Fig. 3). The reflectors were fixed endways, and could be made to give either concentrated or extensive distribution. The exterior finish of the reflector was chosen to suit the colour of the material on which it was fixed. He saw no reason why simple angle units could not be fixed behind the pillars of a church. The installation cost could be comparatively small, and there were such a wide range of reflectors available to give the different distributions that it should be easy to choose a suitable type. Fig. 4 shows a range of such reflectors, together with their polar distribution curves. Where the cost of concealed lighting or diffusing fittings was prohibitive his Company had installed direct lighting reflectors overhead and put them in lanterns to make the daylight effect a little more ornate. At night time no light came through the lanterns. He would like the Author's views on lighting of that description. He showed a view of the chancel of a church at Plaistow lit by means of gas floor standards (Fig. 5), and he showed the effect of substituting two 60-watt lamps and trough reflectors on either side behind the pillars (Fig. 6). He hoped Mr. Darch's paper would be widely circulated, and that a better standard of church lighting would result.

Mr. R. LANGTON COLE, F.R.I.B.A., said he entirely agreed with the lecture as a whole. He also agreed with a previous speaker that the amount of lighting in a church should certainly not be overdone. Some communities might like something like a lecture hall, but he thought the majority preferred the lighting demure—not too strong—but, after all, it was largely a matter of control. It should be capable of being controlled. At some parts of the service more light was wanted than at others. Some of the most beautiful illustrations of daylight lighting they had seen were from Italy, where a large light could be obtained through a small hole.

The best instances of daylight lighting were those of west window lighting. A church with a large west window and small lights down the aisle was thoroughly lighted by daylight, the light flowing towards the preacher. St. Mark's, Venice, was an example, and also the beautiful little Church of the Holy Wisdom at Kingswood, near Banstead. The window was large, and the whole of the light flowed forward on to the splendid apse. That emphasised the point that the light should come from concealed sources from the west and flow towards the east. Those churches in which the light source was entirely concealed, generally on vaults in the roof, seemed admirable. The majority of modern churches had not those vaulting pillars. In those cases they wanted some means for concealing the brackets referred to by a previous speaker, which would not be very beautiful if exposed.

Another point was in regard to special lighting which was perhaps required

more in the Roman churches than the English. In the Church of St. Gudule, Brussels, a statue of the Virgin was softly illuminated with a dim light which seemed to come from nowhere and the rest of the chapel was almost dark. That was a chapel for devotion only, and the central figure being softly illuminated, and the rest in darkness, had a very beautiful effect. They did not necessarily want an illumination of the whole building.

Mr. J. S. Dow said that the general principles put forward by Mr. Darch for the artificial lighting of churches should meet with acceptance, but he thought that he had hardly made sufficient allowance for the influence of tradition and custom in some places of worship. Such traditions were often tenaciously adhered to, and the lighting expert had to accept them, and to try, while doing so, to provide satisfactory lighting as well.

As an instance of how the influence of tradition varied, he might mention two synagogues in London. The first of these, the Bevis Marks Synagogue, in the east of London, possessed a number of fine chandeliers in the Dutch style, which had been presented early in the history of the synagogue and were valued very highly. The authorities were determined that the original lighting by these chandeliers should be preserved entirely, and they still used candles in the chandeliers just as they used to do many years ago. In fact, he understood that one firm was commissioned to make these special wax candles in exactly the same way as had always been done.

In another synagogue in the West End there were also special chandeliers and fittings of Moorish or Eastern design which had been renovated and retained. The authorities, however, had agreed to the introduction of electric light and to the adaptation of modern glassware to the existing fittings, provided certain requirements were complied with. They had even sanctioned the addition of new supplementary fittings, in which, however, the original design was copied. There were various special points that occurred in connection with these designs, one being the necessary absence of anything resembling the cross associated with Christian worship.

The point he wished to emphasise was that in both cases tradition had an influence, but of varying extent. In the one case no alteration whatever in the original lighting was permissible, in the other modifications involved in the introduction of modern lighting were accepted; but the original fittings were retained, and such a step as the scrapping of the old fixtures and the introduction of indirect lighting from bowls of modern design would not have been tolerated. Fuller particulars of these two installations would be found in the Journal of the Society.

While he (Mr. Dow) agreed with Mr. Darch as to the importance of eliminating glare, and especially lights falling within the direct range of view, he thought that Mr. Darch's ideas as to the degree of screening necessary and the limiting angle of view were somewhat stringent. Most people would be satisfied if lights fell outside an angle of 30° with the direct range of vision, whereas Mr. Darch desired 60°. Again, while it was right that all sources (except possibly those mounted on a light coloured roof) should be screened, he thought that modern translucent glassware diminished their brightness sufficiently, provided that they fell outside the angle indicated above.

He (Mr. Dow) was somewhat averse from using opaque shades in churches, unless they were very artfully contrived, and he thought that some of the arrangements of opaque shades suggested by Mr. Darch might give rise to unsightly shadows. Success in using such shades naturally depended very greatly on the degree of reflection from light surfaces on walls and ceiling.

Mr. L. Gaster said that Mr. Darch had evidently given great care and thought to the preparation of his interesting paper. He was sorry that the Lord Bishop of Westminster had been unable to be present, but in his letter explaining his unavoidable absence from town he had expressed the opinion that the subject of church lighting was of great importance and deserved full discussion.

He (Mr. Gaster) had been responsible for the electric lighting of one of the synagogues mentioned by Mr. Dow, and he had also had experience of lighting conditions in other synagogues in London, in which the requirements again presented new features. Almost invariably one found that there were special wishes of the authorities to be taken into account, and it was necessary, while providing adequate lighting, to practise economies. In the cases that had come under his notice the adjustment of the lighting, according to the nature of the service, played a most important part in achieving economies. He entirely agreed that when the congregation had to join in the service and read small print, a fully adequate illumination for reading was necessary, and he wished that such extremely small type, which was unduly trying to the eyes, especially of children, could be avoided, and larger, more legible, type substituted, even if this necessitated the printing of several volumes.

Apart from the regulation of the lighting according to the importance of the service and the size of the congregation, there were special occasions when the full lighting was desired, as an element of rejoicing. This was the case, for example, when weddings were celebrated, and when a fee was paid which would cover the extra illumination allowed. Another form of lighting, of which some beautiful examples had been shown by Mr. Bush, and which might be more generally studied, was the lighting of special memorials, texts, or other devices, by concealed lamps. The synagogue at St. Petersburgh Place, referred to by Mr. Dow, utilised a special series of concealed lights to illuminate the golden lettering above the altar, so that this section of the building "stood out" in sharp relief to the rest of the interior.

In dealing with the lighting of churches one must have a certain degree of sympathy with the congregation and an appreciation of the nature of the worship, and he felt that this was one field where the architect and the lighting expert could co-operate in a very satisfactory manner.

He wished to propose a hearty vote of thanks to Mr. Darch for his interesting paper.

Mr. DARCH, replying to the gentlemen who had entered into the discussion, desired to thank them for their appreciative and kindly criticism of his paper, and in answer to Mr. Goodenough, said:—

Having succumbed to the fascination of nearly every available cathedral and abbey church and enjoyed the calm of those sacred relics of mediæval life, I am quite with him in his admiration of the beauty and usefulness of stained glass windows. But my concern is for present-day practical needs in the hundreds of churches and chapels around us. I quoted a vicar who complained of the effect of his stained glass windows, I thereupon visited that church and found it impracticably gloomy. Let the stained glass be as dense as possible in east or other windows facing the people, but clerestory windows and west windows should admit plenty of light. My subject, however, was artificial lighting, and those who have experienced an ample but not garish illumination realise how pleasantly it clings to the memory. It goes without saying that good lighting will not absolutely compensate for a dull preacher. I had assumed a fair average. My point is that good lighting, as I have defined it, increases comfort, gives visual pleasure, and when a preacher's face is well lit his sermons are better appreciated. But a badly lighted church will damage the finest sermons and destroy ease; and is it not a fact that nine-tenths of our churches and chapels are badly lit? As regards taking into account the particular religion that was practised, I deferred to that in a short paragraph (p. 143), but I was mainly concerned with the vast majority of British places of worship in which there is nothing abnormal.

Mr. Ritchie is an earnest reformer in the art of illumination, and his expressions of appreciation of my paper are encouraging. I quite agree that in some parts of the service the "dim religious light" is desirable; I think that my Rule 6 meets this point and explains why. Mr. Ritchie's views as to the natural lighting of a church and the aims of the designer are those that I have tried to bring before the Society.

The Chairman did not seem to realise the sleepy effect of glare. It is the

compulsory closing of the eyes that induces sleep; the fact has been frequently pointed out. There is a curious passage in Acts xx, 7, 8, 9, with a strong inference that the unfortunate Eutychus fell asleep as the result of the " many lights," otherwise it seems unnecessary to have mentioned them.

I am in agreement with all Mr. Bush told us, excepting as to his justification of front lighting. I think that diffusing bowls are very useful, and I should not hesitate to use them; but my objection was to the placing of bare or glass covered lights before the eyes of the people and around the preacher's head. The church that can afford those bowls need not submit to their glare, if so placed, when the trouble can be so easily and cheaply avoided by the " Method B," which I was compelled to describe so briefly. The reason why I gave no opinion as to the types of fittings employed was because I set out to deal with the principles and art of illumination and had no space for practical fitting.

Mr. Langton Cole's excellent comments are worth reading more than once, and leave me nothing to say unless I enlarged upon them.

To Mr. Dow's claim for tradition and custom and to lovers of the past (and I am one myself), I say that only those traditions and customs can be maintained that harmonise with modern life. It is not the traditions or the customs that constitute the religion. We are but creatures in a changing world, and religious thought with its lighting and other customs must keep abreast of education and general progress; we must scrap the effete or the churches will fall under the Juggernaut of time, and the spark of religion will fly elsewhere.

Mr. Gaster's remarks are so much to the point that I have nothing to say to them except to express my thanks.

Obituary.

MR. G. M. LIGHT.

It is with great regret that we record the death of Mr. G. M. Light, of Messrs. Light and Fulton, Solicitors, who passed away on May 1st. Mr. Light acted as Honorary Solicitor of the Illuminating Engineering Society from its commencement in 1908 up till the time of his death. He was admitted as a solicitor in 1882, and for thirty years or more acted personally or as a partner in the business as Solicitor for the New South Wales Government. From about August, 1914, onwards he acted as Registrar of the Whitechapel County Court. His kindly and genial disposition endeared him to all his friends, and to his native shrewdness was added a vein of humour that made him an excellent conversationalist. His death has been the subject of general regret amongst his many friends in the legal and other professions.

PERSONAL.

We have pleasure in recording that Mr. D. O. Light has kindly consented to continue his father's connection as Honorary Solicitor to the Illuminating Engineering Society.

WISCONSIN (U.S.A.) REGULATIONS FOR AUTOMOBILE HEADLIGHTS.

A useful bulletin has been issued by the Industrial Commission of Wisconsin (Madison, Wis., U.S.A.) summarising regulations for automobile headlights in that State, which as regards candlepower of beam, limitations with a view to diminishing glare, etc., are in close accordance with the recommendations made in the contribution by Dr. C. H. Sharp and Mr. W. E. Little in our last issue. Comprehensive explanatory data are included, such terms as " foot-candle," " photometer," etc., being defined, and the distribution of light from various kinds of lenses and mirrors is illustrated by diagrams.

THE MAINTENANCE OF LIGHTING SYSTEMS.

An article by W. Harrison and J. R. Colville in the *Electrical World* summarises the advantages of efficient maintenance of lighting installations. It is customary to allow for the deterioration of lighting owing to effects of dust, ageing of lamps, etc., by a "depreciation factor," which may amount to 1·2 in fairly favourable circumstances and 1·5 in cases where there is much smoke and dust. But the use of such a factor implies that lamps of higher consumption are used than should be necessary if the installation is efficiently maintained. It is therefore preferable to ensure the utmost efficiency by regular and systematic care of lighting appliances.

In order to show the extent to which the available illumination may be diminished by neglect in this respect, the authors quote the example of an office where the desk-illumination was found to be 2·7 foot-candles. The reflectors had been wiped out at fairly frequent intervals, but were nevertheless taken down and washed. This resulted in an increased illumination of 3·7 foot-candles. Next, it was found that the lamps had been in service for more than two years, and that in some cases they were intended for a voltage somewhat higher than that actually used. New lamps were accordingly substituted, and this led to a further increase in the illumination to 5 foot-candles. Originally the office had been finished with a paint which was found to reflect 75 per cent. of the light striking it, but it had become so discoloured through two and a half years' use that it now only reflected 50–55 per cent. Accordingly the office was repainted in the original tone, and this increased the illumination up to 7 foot-candles. Thus by the three measures described the illumination had been more than doubled without any increase in consumption.

In practice it is found that wiping out reflectors is only about two-thirds as effective as washing. In favourable circumstances the loss of light during one month may amount to 10–25 per cent., in cases where there is much smoke and dust, up to 40 per cent. The accompanying table is presented, showing the suggested period of cleaning for direct and indirect lighting.

Nature of Conditions.	Direct Lighting.		Indirect and Semi-Indirect Lighting.	
	Interval in days if units are wiped out.*	Interval in days if units are thoroughly washed.	Interval in days if units are wiped out.*	Interval in days if units are thoroughly cleaned.
Very dirty	3	5	—	—
Dirty	7	10	5	7
Average	15	20	10	15
Clean	30	40	20	30

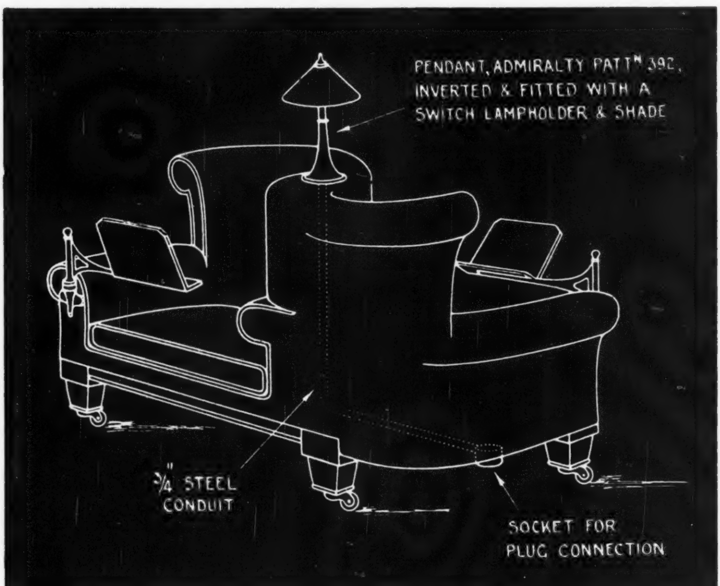
* Washing every third or fourth interval is assumed.

It is not difficult to show that the cost of the loss in illumination through neglect of periodical cleaning may exceed considerably the expense involved in such overhauling. Much, however, depends on the way in which fittings are arranged so as to facilitate the cleansing process, and in the article referred to examples of fittings so suspended as to be quickly and safely removed for treatment are shown.

A CONVENIENT ARMCHAIR LIGHTING FITTING.

The "Unilux" twin armchair shown in the accompanying illustration is the invention of Dr. R J. E. Hanson, O.B.E., ophthalmic surgeon to the Admiralty, and presents several interesting features. It will be noted that the twin chairs are each provided with a convenient book-rest, but are served by a single light-source, permanently placed so that each reader receives light over the left shoulder.

In ordinary drawing-rooms this rule is frequently not complied with, chiefly because the position of the chair with respect to the source of light is variable, and readers cannot be trusted always to manipulate their chair into the best position. It is not always practicable to fix the relative positions of light and chair, but in some circumstances, in club reading-rooms, for example, this can be done with advantage, and in such cases we should imagine that the type of chair illustrated would prove very acceptable. The plug-socket connection naturally requires care. In the illustration the chair is shown equipped with casters, but these could be restrained by means of rubber or wooden sockets in the floor so as to prevent the chair shifting; or, alternately, the chair-legs could be made to drop direct into sockets, thus removing any possibility of the electric connection being broken by a sudden movement.



TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

CHURCH LIGHTING WITH HOLOPHANE GLASSWARE.

The subject of Church lighting is receiving a great deal of attention since the war, and the introduction of the "Half-watt" type lamp has done much to assist in providing satisfactory illumination results over comparatively large areas and with greater consideration to æsthetic requirements than has hitherto been possible. The selection of suitable lighting appliances for use with such lamps is naturally of great importance. By means of prismatic devices such as the Holophane Bowl units it is possible to provide efficient and well diffused general lighting results without undue multiplicity of lamps and points. Further, by careful selection of the correct types of lighting units and the judicious arrangement of the mounting heights much inconvenience to the congregation due to light sources coming within the range of vision can be avoided.

Large churches without galleries may be effectively lighted by Holophane Bowl units mounted about 16 ft. from the floor, but in the case of Congregational and similar Nonconformist churches the light sources are placed at a considerable height in order to avoid obstruction of vision of the congregation seated in the gallery, in the manner shown in the illustration on the opposite page. By the careful selection of the correct types of Holophane focussing reflectors it is possible to illuminate the main well of the church equally satisfactorily, as with a lower mounting height and without in any way sacrificing efficiency.

Concealed lighting of the chancel is also a method which has gained considerable headway of late, and by the suitable selection and location of relatively few Holophane reflectors mounted directly above the arch one can secure even illumination over the whole of the altar by this method without objectionable shadows being cast.

THE LIGHTING OF THE ALBERT HALL.

We are interested to note that the lighting of the Albert Hall has recently been re-arranged, the new method involving the use of sixteen 1000-watt Mazda gas-filled ("Half-Watt") lamps in large Mazdalux reflectors. This hall, it will be recalled, presents interesting features as a lighting problem. The great height of the lamps, it is stated, eliminates glare, the actual filaments being invisible except when a person leans back in his chair and gazes directly upwards. The illumination is stated to be considerably increased and more uniformly distributed than was the case with the arc lamps formerly employed, and the fact that the lamps do not require frequent maintenance and attention is also a considerable advantage. The method of lighting is one which can be effectively employed in large glass-domed interiors of a similar nature.

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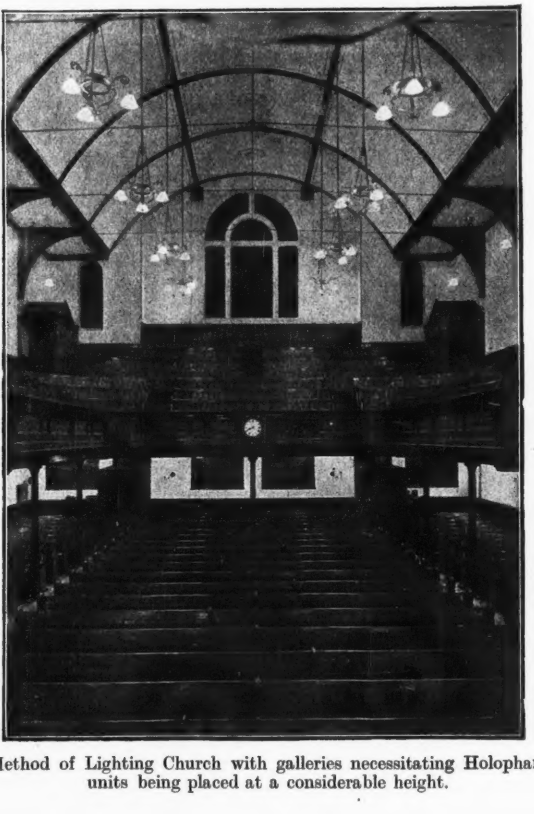

Method of Lighting Church with galleries necessitating Holophane units being placed at a considerable height.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Whittaker's Electrical Engineer's Pocket Book. Edited by R. E. Neale. (*Sir Isaac Pitman and Sons, Ltd., London. pp.* 671. 10*s.* 6*d. net.*)

THE fourth edition of this pocket book has been entirely re-written and contains a great deal of useful information, assembled in a compact and convenient form. The generation, transmission and distribution of electric energy receive exceptionally detailed treatment. Generally speaking the matter is more readable than is usually possible in pocket reference works, and some of the special sections, such as those dealing with traction, electric furnaces, electric welding, and electricity in agriculture, contain matter which is not very generally known. The section on lighting deals with the subject in an up-to-date manner, and good use has been made of the space available. There is much useful tabular matter, a liberal use of illustrations, and an adequate index. The work fully maintains the standard of its predecessors.

Electric Wiring. By W. S. Ibbetson. (*E. & F. N. Spon, Ltd., London.* 1920. *pp.* 463, *figs.* 218. 18*s. net.*)

THIS is the second edition of Mr. Ibbetson's work, which is intended mainly to assist students taking the elementary examination in electric wiring of the City and Guilds of London Institute, and the earlier examinations of other governing bodies in electrical engineering. New matter is included in the sections on lighting, motors and dynamo circuits, and a feature is the new section dealing specially with ship-wiring. There are in all eighteen sections, the earlier ones dealing with general principles, while sections on systems of wiring and jointing, batteries and bells, motor circuits and special problems in wiring follow. A couple of chapters are devoted to glow lamps and arc lamps, and a brief explanation of elementary principles in lighting is given. The work is well illustrated and will doubtless continue to be appreciated by students in electrical engineering.

The Practical Electrician's Pocket Book and Diary. (*S. Rentell and Co., Ltd., London.* 1920. *pp.* 520. 2*s.* 6*d. net.*)

THE new edition of the *Practical Electrician's Pocket Book* shows a further increase in size, 40 pages being added to the bulk for 1919. There is much of interest in the new sections dealing with electrical welding, furnaces, metres and switchgear, etc., and the other matter has been fully revised. The subject of lighting is dealt with adequately, a feature being the use of modern symbols for denoting candlepower in different directions, and the explanation of the lumen and mean spherical candlepower. The tabular data relating to central stations, which have been enlarged, are also useful. In these days of high prices the low figure (2s. 6d.), for which the diary is published, is certainly striking.

The Coolidge Tube. By H. Pilon. (*Bailière, Tindall and Cox, London.* 1920. *pp.* 96, *figs.* 59. 7*s.* 6*d. net.*)

RONTGEN-RAY apparatus has now a literature of its own and this volume dealing with the Coolidge tube is therefore timely. The book is divided into three sections dealing respectively with the design of the tube, its properties, and its value critically examined. Charts are presented showing the nature of the radiation, and such points as the emission of rays from points other than the focus are considered. The book is illustrated by numerous diagrams, and there is a useful chapter at the end on protective devices.

"*Safety First,*" *May,* 1920. (*The Journal of the British Industrial "Safety First" Association, 2-3, The Sanctuary, Westminster, S.W.*1.)

THIS little bulletin contains an account of the First Annual General Meeting of the Association on February 24th, when the President (Lord Leverhulme), the Rt. Hon. G. H. Roberts, M.P., and others delivered addresses. A brief account is also given of the experiences of Mr. G. Bellhouse, C.B.E. (H.M. Deputy-Inspector of Factories), during his recent tour in the United States. The journal is brightly written and interesting, and will, we hope, aid in securing wider publicity for the valuable work of the Association.

6

The ILLUMINATING ENGINEER

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Edited by LEON GASTER

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EDITORIAL.

The Twelfth Annual Meeting of the Illuminating Engineering Society.

At the Annual Meeting on May 11th the Illuminating Engineering Society completed its second Session since the cessation of hostilities in the autumn of 1918, and its twelfth Session since the formation of the Society. The Report of the Council (pp. 175-178) shows that the Society has now completely resumed its pre-war activities, and that during the past Session it dealt with a variety of topics of exceptional interest. The discussion on "Lighting Conditions in Mines, with Special Reference to the Eyesight of Miners," opened by Dr. T. Lister Llewellyn, on February 24th, and the discussion on "Motor-Car Headlights," on March 30th, offered good examples of problems of great national importance on which the Society is in a specially favourable position to assist authorities, while other papers read, notably that by Mr. Martin on "Colour Matching by Natural and Artificial Light," were of great scientific value.

Throughout the session the Society has pursued its traditional methods of enlisting the co-operation of kindred bodies on topics of common interest. The assistance of the bodies concerned with physiology and ophthalmology,

in particular, has been most helpful, both in the discussion of lighting in mines and in the work of the Joint Committee on Eyestrain in Cinemas, whose Interim Report has now been submitted to the London County Council, and is published, with their kind permission, in the present number (pp. 189-193). With this Report, and also with Captain Barber's delightful demonstration of portable cinema outfits at the Annual Meeting, we deal more fully in our subsequent Editorial Notes (pp. 171-2), but we would like just to emphasise the very valuable co-operation of the representatives of the cinema industry in this work, which offers an excellent field for the researches by illuminating engineers.

We hope that several of these discussions will lead to further constructive investigations by joint committees, acting in co-operation with the authorities concerned. The work of the Departmental Committee on Lighting in Factories and Workshops furnishes a useful precedent, and we trust that similar action will be taken by the Home Office in regard to lighting conditions in mines. We hope that in the near future the recommended statutory power to demand adequate lighting in factories will be introduced into the Factory Acts in this country ; this step will doubtless have an important and beneficial action on conditions of industrial lighting. We have met with several instances recently of the changed public outlook in this matter. Manufacturers in this country are now quick to recognise the advantages of good lighting—a result that is due very largely to the steady educational efforts of the Illuminating Engineering Society, and to kindred bodies such as the British Industrial "Safety First" Association, whose persevering propaganda in the cause of industrial safety deserves every encouragement.

Interest in these matters is not confined to this country. During his recent visits to Brussels and to Czecho-Slovakia (referred to in our last issue), the writer had opportunities of explaining to authorities the steps taken for the advancement of knowledge of illuminating engineering in this country, and found evidence of a general appreciation of the importance of the subject. There can be no doubt that the present moment, when in all the leading countries a process of reconstruction is going on and minds are in a receptive state for new ideas, offers exceptional opportunities for such educational work abroad. We are therefore much gratified to see the resumption of the international section of the Society's work, through congresses and exchange of views with experts in foreign countries.

It will be noted that the National Illumination Commission has now resumed active work in this country, and at the last meeting it was resolved that in the opinion of the Committee a meeting of the International Illumination Commission should be held in Paris next year, to discuss technical questions, amongst which, it was suggested, industrial lighting should receive consideration.

We are glad to record an improvement in the revenue of the Society, the new conditions in regard to membership and subscription having been without detrimental effect on the numbers of the Society. At the same time it must be recognised that the Society still needs a greatly increased membership in order that its work and influence may be extended in the way desired, and we hope that existing members will therefore take every opportunity of interesting others in the Society's work and enlisting their co-operation.

Developments in Portable Cinema Outfits.

The paper on the above subject read by Captain J. W. Barber, C.B.E., at the Annual Meeting of the Illuminating Engineering Society on May 11th, accompanied by some delightful demonstrations of portable cinemas, showed clearly that there has been considerable progress in this field. While the portable cinema is still in the stage of development, it may eventually become a familiar object in the home or the school, where it has many possible applications. In educational work, as a supplement to the history or geography lesson, in assisting the study of Nature, and especially in revealing and analysing movements, the portable cinema has an interesting future.

Already we have a variety of departures from the ordinary form of stationary apparatus erected in a fully-equipped theatre. There is firstly the motor-van cinema, "travelling" rather than portable, which was widely used for propaganda work during the war, and with the design of which Captain Barber was himself associated. Next we have the truly portable "suit-case" cinema outfits which can be carried about from place to place, but needs the use of an ordinary electric supply to furnish the source of light, and in some cases the motor-power. The source of light is here a focus-type gas-filled electric lamp. A highly interesting form of apparatus, shown, we believe, for the first time in this country, was the cabinet automatic cinema, which merely requires switching on to an ordinary electric supply for the whole process to commence and the pictures appear on the screen. Finally we have the familiar pathescope apparatus, which is entirely hand-driven, and is independent of an electric supply, current being furnished by a small electric lamp fed from a magneto.

Considering the small bulk of the apparatus, the pictures obtained were promising. There is, however, scope for further design of the light source with a view to getting the maximum amount of light through the lens-system, and here the illuminating engineer may be able to suggest improvements, as also in another important portion of the apparatus, *i.e.*, the form of screen used. The tendency is to use screens coated with aluminium powder, or similar metallic surfaces, in order to increase the brightness of the image, but such screens are best used only in long narrow rooms as there is considerable loss in brightness when the screen is viewed at oblique angles.

A vital point, on which the valuable experience of Mr. E. Ridley, of the L.C.C. Fire Brigade, and Major A. Cooper-Key, of the Home Office Explosives Department, was afforded in the discussion, is the preservation of safe conditions of exhibition. Naturally care must be exercised in the case of portable apparatus that may be placed in relatively inexperienced hands, and used in places where the ordinary safeguards usual in cinema theatres may not be available. This applies especially to the insertion, handling and removal of films, and their storage. Not only do inexperienced operators require guidance in the handling and storage of films in such a manner as to prevent injury and deterioration, but they should realise that the main danger of fire occurs in dealing with a loose film, outside the apparatus. Such dangers would be eliminated by the introduction of a non-inflammable form of film, and we welcome the assurance of the representatives of the cinema industry that they will gladly devote themselves to this problem if the exact requirements of such a film can be precisely defined. It only remains to thank Captain Barber and those who assisted him in this interesting exhibition of apparatus.

The Report of the Joint Committee on Eyestrain in Cinemas.

We are reproducing in this number, by the kind permission of the London County Council, the Interim Report of the Joint Committee appointed by the Illuminating Engineering Society to "inquire into the possible causes of eyestrain in cinemas, and the best means of removing them." The Committee was formed to deal with an inquiry addressed to the Society by the L.C.C. last year, and affords a good instance of the characteristic procedure of the Society in co-operating with kindred bodies. The Committee received the co-operation of representatives of the Council of British Ophthalmologists, the Physiological Society and the Cinema Industry, and was also fortunate in receiving the help of three officers of the L.C.C., Dr. James Kerr, Dr. C. W. Kimmins, and Mr. E. Ridley, all of whom rendered most valuable assistance.

Being composed of experts in their respective fields, the Committee did not feel it necessary at this stage to invite outside evidence. Their conclusions are based on the experience of the physiological and ophthalmological experts in regard to the effect of various conditions on the eye, and on the actual experience of all the members of the Committee who visited a considerable number of cinema halls in the London area. The Committee made observations of illumination and brightness, witnessed films from various points in the halls, and subsequently drafted recommendations expressing, in a convenient form, the results of this experience.

The subject offers a very wide field for investigation, and the Committee, in this interim report, have devoted attention chiefly to one point of primary consequence, *i.e.*, the effect of proximity of seats to the screen. Experience showed that visual discomfort arises largely through effort involved in raising the eyes to observe pictures presented at an unduly high level; accordingly importance is attached to the recommendation that the angle of elevation, measured to the top of the picture, should not exceed 35°, while a limit to the lateral angle of view (25°) is also recommended.

Other matters discussed are the origin of flicker, the effect of imperfections in films and apparatus, the desirable brightness of screen and the conditions of artificial lighting in theatres. On these subjects the Committee do not present formal recommendations at this stage, but they suggest general principles which should serve as a useful guide to cinema producers. The Committee are satisfied that the requirement that the illumination in all parts of a hall should not be less than one-fortieth of a foot-candle can be readily satisfied without prejudice to the appearance of the picture, and they point out the desirability of a gradual increase in illumination, passing from the front to the back of the auditorium—a practice that has already been adopted with advantage in some theatres.

In undertaking this inquiry the Illuminating Engineering Society has once more demonstrated its facilities for bringing together the various interested parties, and in reconciling somewhat conflicting points of view. The co-operation of the representatives of the cinema industry has been most helpful to the Committee throughout the investigation. We welcome this appreciation of the wisdom of a policy of accepting scientific guidance, irrespective of any temporary financial inconvenience that may be involved, in the expectation that such an inquiry must tend to the ultimate benefit of the industry as well as that of the general public.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL MEETING.

(Proceedings at the Annual Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, May 11th, 1920.)

THE Annual Meeting of the Illuminating Engineering Society was held at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, May 11th, the chair being taken by Dr. JAMES KERR. The Minutes of the last meeting having been taken as read the HON. SECRETARY announced the names of the following applicants for membership :—

The following resolution was then moved by Mr. A. BLOK, seconded by Mr. R. C. BUSSELL, and declared carried unanimously :—

"That the Annual Report of the Council for the Session 1919–1920 be adopted and that a vote of thanks be moved to the Council and Officers of the Society for their services during the past session."

Balmford, W.	Manufacturing Electrical Engineer, 28, Queen's Road, Birmingham.
Barber, Captain J. W., C.B.E.	Cinema Expert, 60, Welbeck Street, Cavendish Square, London, W.1.
Donnison, E. G.	Engineer, Cornwall House, Cornwall Street, London, S.W.1.
Plummer, R. G.	Managing Director, Ceag Mines Supply Co., Ltd., Barnsley.
Severn, E. M.	Asst. Lighting Superintendent, South Metropolitan Gas Co., 709, Old Kent Road, London, S.E.

The Hon. Secretary then proceeded to read in abstract the usual Report of the Council for the Session (pp. 175–178). Allusion was made to various important topics dealt with during the Session, and the useful work being accomplished by the various committees of the Society, which had now completely resumed its normal activities.

Mr. L. GASTER, in briefly acknowledging this expression of appreciation of the services of the Council and Officers, mentioned that Mr. A. P. Trotter, the President, had removed from London to the country, and while still taking an interest in the Society's work, had suggested that the Council should now endeavour to find a suitable successor as

President. The Council, in expressing their deep appreciation of Mr. Trotter's services to the Society, had requested him to allow his name to be retained as President until a suitable successor could be found. Meantime he felt sure that all members would join in this expression of appreciation of the services he had rendered both to the Society and to the advancement of scientific knowledge on photometry and illumination.

The following resolution was then moved by The CHAIRMAN, seconded by Mr. L. GASTER, and carried unanimously:—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received."

This terminated the formal business before the meeting, and the Chairman then called upon Captain J. W. BARBER, C.B.E., to read his paper on **"Recent Developments in Types of Portable Cinema Outfits."** The lecture, which was illustrated by a series of demonstrations of different forms of portable cinema projectors, was much appreciated.

Captain Barber pointed out that these types of apparatus, which, still in the developing stage, opened to the cinema new fields of usefulness. The technical problems involved in the optical design of the projector were of great interest to illuminating engineers, and in bringing this subject before the Society, he hoped that he would be instrumental in inducing its members to aid in the solution of various outstanding problems.

An interesting discussion ensued, in which The CHAIRMAN (Dr. JAMES KERR), Mr. F. R. GOODWIN (President of the Cinematograph Exhibitors' Association), Major A. COOPER-KEY (Home Office, Explosives Dept.), Mr. E. RIDLEY (London Fire Brigade), Mr. J. C. ELVY, Mr. A. BLOK, and Mr. A. L. ROBERTS took part. Captain J. W. BARBER briefly replied to the various points raised in the discussion.

The CHAIRMAN, in proposing a cordial vote of thanks to Captain Barber and to the firms who had contributed to the interest of the evening by the exhibition of apparatus, remarked that the portable cinema presented an interesting field for study, and had considerable possibilities for educational work. It was evident that considerable progress had already been made in the design of such apparatus, which offered great opportunities for the ingenuity of lighting experts.

In conclusion it was announced that the first meeting of the next session would take place in November next.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

At a meeting of the National Illumination Committee on June 21st, the resignation of the Chairman, Mr. A. P. Trotter, on account of his retirement to the country, was accepted with great regret, and Major Kenelm Edgcumbe (Vice-Chairman) was elected as his successor. Mr. C. C. Paterson, representing the Illuminating Engineering Society, was elected to the vacant position of Vice-Chairman.

Dr. E. P. Hyde attended the meeting as a delegate from the United States National Illumination Committee, and gave an account of his interviews with various members of the National Committees in France, Italy, Switzerland, Belgium and Holland.

It was proposed by Mr. Butterfield and seconded by Mr. Gaster that "in the opinion of this Committee a meeting of the International Illumination Commission should be held in Paris next year to discuss technical questions," and this proposal was carried unanimously.

Dr. E. P. Hyde and Mr. L. Gaster suggested that the matter of legislation in regard to the conditions of illumination necessary for health, safety and efficiency in factories should form one of the subjects for consideration.

REPORT OF THE COUNCIL FOR THE SESSION

(November, 1919—May, 1920).

(Presented at the Annual Meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 8 p.m., on Tuesday, May 11th, 1920.)

DURING the past session there has been a return towards normal conditions in regard to lighting, and the Society has been able to adhere more closely to its usual course of work. It has had the pleasure of welcoming back the majority of its members who were formerly serving with the forces or engaged on special war work and continues to receive an encouraging influx of new members. The arrangement by which the Presidents of kindred associations become during their tenure of office members of Council of the Illuminating Engineering Society, has been extended and now applies to the following bodies :—

The Illuminating Engineering Society in the United States; the Illuminating Engineering Society in Japan; the Institution of Gas Engineers; the Institution of Electrical Engineers; the Council of British Ophthalmologists; the Ophthalmological Society; the Physiological Society; the Electrical Contractors Association; and the Association of Railway Electrical and Telegraph Engineers.

The Council record with regret the death of three members of the Society during the past session—Professor A. G. Vernon Harcourt and Sig. L. Pontiggia, both of whom were Honorary Members, and Mr. S. D. Chalmers, who was associated with the Dept. of Technical Optics at the Northampton Institute. Obituary notices have appeared in the official organ.

Following the last annual meeting a special summary of the work of the Society during the period 1909–1919 was published in THE ILLUMINATING ENGINEER, and has since been reprinted in pamphlet form. The pamphlet has proved of considerable value in interesting others in the work of the Society.

MEETINGS OF THE SOCIETY.

Several of the meetings held during the past session have been of great interest, and have aptly illustrated the utility of the principle adopted by the Society of securing the co-operation of other bodies on subjects of common interest.

In accordance with the usual practice, the opening meeting on November 25th, 1919, was devoted to a review of progress, and exhibits of novel lighting devices of various kinds. An address on "Lambert and Photometry" was delivered by the President, and a report on "Progress during the Vacation" by the Hon. Secretary. A report on "The Position of the Metal Filament Lamp and Fittings Industry at the Present Time" was presented by the Committee on Progress in Lamps and Lighting Appliances. It is hoped that reports of this nature, dealing with progress in the chief illuminants, will form a regular feature at the opening meetings of future sessions. Mr. L. C. Martin exhibited the Sheringham Daylight unit and Mr. P. Freedman a variety of new forms of Pointolite Lamps. Mr. Haydn T. Harrison showed a new form of illumination-photometer which had several interesting features.

On December 16th, 1919, Captain W. A. Howells, O.B.E., gave a lecture on "The Art of Camouflage," which was fully illustrated by lantern slides, and discussed many problems in visibility, some of considerable interest to the illuminating engineer.

At the next meeting, on January 27th, Mr. L. C. Martin read a paper on "Colour-Matching by Natural and Artificial Light," and a number of exhibits dealing with lighting appliances and instruments for colour-matching work were shown. Some valuable supplementary contributions were received from Mr. M. Luckiesh

and Mr. N. MacBeth summarising progress made in the use of "Artificial Daylight" in the United States, and the discussion furnished a useful review of knowledge in this important field.

The subsequent gathering on February 24th proved to be one of the best attended meetings of the Society. On this occasion Dr. T. Lister Llewellyn read a paper on the subject of "Lighting Conditions in Mines with special reference to the Eyesight of Miners" a supplementary contribution being presented on the same subject by Dr. H. S. Elworthy. The co-operation of the Council of British Ophthalmologists and the Ophthalmological Section of the Royal Society of Medicine proved most valuable at this discussion, ophthalmic surgeons having special knowledge of the subject coming from all parts of the country to attend the meeting. The paper and subsequent discussion dealt mainly with the prevalence of "miner's nystagmus," and revealed a general consensus of opinion that inadequate lighting is one of the most influential factors in the causation of this disease, which can best be remedied by the joint efforts of the lighting expert and the ophthalmologist.

The meeting on March 30th was likewise devoted to a subject of considerable public importance. In view of the interest aroused in the interim report issued by the Advisory Committee on Lights and Vehicles, sitting under the Ministry of Transport, it was considered that a general discussion on "Motor Car Headlights and Rear Lights in relation to Traffic Requirements" would be opportune and Mr. J. W. T. Walsh kindly consented to open the discussion, to which representatives of the leading bodies interested in motor traffic were invited to be present. Here, again, the paper and discussion provided a useful survey of existing conditions, which should form the basis of further experiments.

The final meeting, prior to the Annual Meeting, on April 20th was devoted to a paper on "The Artificial Lighting of Churches" by Mr. J. Darch, in which the fundamental principles to be observed in lighting churches were outlined and illustrated by numerous diagrams.

Work of Committees.

A considerable amount of work has been done by the Joint Committee appointed by the Society, to inquire into the subject of "Eyestrain in Cinemas," in response to an inquiry addressed to the Society by the London County Council. In the course of their investigations the members of the Committee visited a number of cinema halls in the London district, and witnessed a series of demonstrations, and the inquiry has afforded a useful illustration of the benefit of co-operation between ophthalmic surgeons, physiologists, and lighting experts.

The constitution of this Joint Committee, on which the Illuminating Engineering Society, the Council of British Ophthalmologists and the Physiological Society are represented and which also receives the assistance of officers of the L.C.C. and delegates from the cinema industry, has already been published in the official organ. The Committee have prepared an Interim Report which, it is hoped, will shortly be placed in the hands of the London County Council with the request that, after consideration by that body, permission should be accorded for publication in The Illuminating Engineer.

The Joint Committee on Railway Lighting, the formation of which was announced in the Report of the Council for the previous session, has also been at work, and has recently received the requisite sanction from the authorities for the carrying out of tests on the chief railways. It is hoped that during the next session a considerable amount of useful work will be done by this Committee.

The Committee on Progress in Lamps and Lighting Appliances, as already noted, furnished the Society with a Report at the opening of the present Session, and it is hoped that similar reports dealing both with electric and gas lighting will be available at the opening meeting in November next.

As has been our experience in the past, the present session has suggested several other subjects which might well be studied by joint committees. In the course of the discussion on "Lighting Conditions in Mines with special reference

to the Eyesight of Miners" Mr. Bernard Cridland suggested the desirability of a systematic inquiry by a Joint Committee to settle many points in connection with the causation of miner's nystagmus. It is proposed that a suitably constituted Joint Committee, on which the Illuminating Engineering Society, the Council of British Ophthalmologists and the Royal Society of Medicine should be represented, to undertake simultaneous investigations into conditions of illumination in mines and the eyesight of workers, and it is hoped that this project will receive the sympathetic co-operation of the Home Office, as a useful supplement to the Committee already sitting on Miners' Lamps.

It is also possible that an opportunity for the services of the Society may be afforded by the further consideration of motor car headlights, regarding which the Society has already been in communication with the Ministry of Transport.

Co-Operation with Other Bodies.

The Society has maintained its cooperation with various other bodies, in addition to those to which reference has already been made. The London "Safety First" Council and the British Industrial "Safety First" Council have been continuing their valuable work, and through their various committees have dealt with various problems in which the use of light as an aid to safety is concerned. The latter body has recently issued a pamphlet summarising the advantages of good lighting in the interests of safety and efficiency, and it is hoped that one section of its activities will be the collection of data on the chief causes of accidents, amongst which inadequate lighting will receive consideration.

The Society was again invited to co-operate in connection with the second British Scientific Products Exhibition held at the Central Hall, Westminster, during July 3rd to August 5th, 1919, and the Council note with pleasure the intention of making this Exhibition an annual event. A lecture on "Scientific Lighting and Industrial Efficiency" was read by Mr. L. Gaster, in which the important part played by lighting in facilitating production was explained.

A paper on "Industrial Lighting in relation to Efficiency" was also read by Mr. Gaster before the Royal Society of Arts on March 24th, 1920, in the course of which the need for international treatment of this subject was emphasised. Dr. T. M. Legge, H.M. Chief Inspector of Factories, who opened the discussion, stated that he hoped that the desired general statutory provision requiring adequate lighting would be introduced into the Factory Act very shortly.

International Co-operation in Illuminating Engineering.

One gratifying sign of the restoration of normal conditions in regard to illuminating engineering has been the recommencement of international co-operation. In the years preceding the war the Society derived great benefit from the assistance of its corresponding members in various parts of the world. During the war this co-operation was unavoidably checked, but during the present Session there have been several occasions on which valuable contributions have been received from abroad in connection with discussions, notably those on "Colour-matching by Natural and Artificial Light," "Motor-Car Headlights," and "Lighting Conditions in Mines."

Another feature in the Society's programme has been its regular participation in International Congresses, at which various aspects of illumination were discussed. The forthcoming Congress of the Royal Institute of Public Health, at which the Society will be represented in the person of its Hon. Secretary, will furnish an opportunity of renewing many connections temporarily severed, and recommencing the work that had been initiated before the war on such subjects as industrial lighting, a matter which, it is felt, especially deserves international treatment.

Attention has been drawn to the renewal of work by the National Illumination Committee in this country, which will doubtless prove an indication of the restoration of the International Illumination Commission which came into existence a few years before the war.

The Council observe with pleasure the continued progress of the Japanese Illuminating Engineering Society, some particulars of which have been published in the official organ, while other information has been afforded by its first President, Dr. Yamakawa, who was recently on a visit to this country.

The Illuminating Engineering Society in the United States has been continuing its work with its usual energy, and it is to be observed that there are now six States which possess codes of industrial lighting. There should therefore be many opportunities for fruitful co-operation between these various bodies in the advancement of illumination.

FUTURE PROSPECTS OF THE SOCIETY.

The new arrangement, whereby two classes of membership (*i.e.*, members and associates) are recognised, has operated satisfactorily during the current year, and the increase in subscription for members has been well received and has not exercised a detrimental effect on the numbers of the Society. The revenue has accordingly shown a considerable increase during the past session, but it is still desirable that an increased membership should be attained, with a view to extending the work and influence of the Society. Members whose subscriptions have fallen into arrear during the war but who now desire to resume their participation in the Society's work are particularly requested to send their contributions to the Hon. Secretary.

In view of the new opportunities offered for the services of the Society its prospects for the future appear satisfactory. The Council are now preparing the programme of papers for the next session and invite suggestions from members who are prepared to read papers. Among the subjects selected for early treatment are "Ship Lighting" and "The Use of Light in Aerial Navigation," and the Aeronautical Society have already been approached with a view to holding a joint meeting for the discussion of the latter subject.

By order of the Council,

L. GASTER,
Hon. Secretary.

GLASGOW LIGHTING ASSOCIATION.

We have received an account of the recent proceedings of the Glasgow Lighting Association, to which reference has recently been made in this journal.* We observe that on May 19th a visit was paid to the works of Messrs. Stewarts and Lloyds at Tollcross, while June 9th was devoted to a social excursion on the Firth of Clyde.

A useful step has been taken by the Association in publishing a list of works on the subject of illumination and photometry available in public libraries of the City of Glasgow, a key-letter giving the reference in each case to the particular library where each work is to be seen. The list so compiled is quite a comprehensive one and should be of considerable service to members of the Association.

* March, 1920, p. 108.

ROYAL SANITARY INSTITUTE.

Thirty-first Congress.

We observe that the thirty-first congress of the Royal Sanitary Institute is being held in Birmingham during July 19th–24th, under the Presidency of the Rt. Hon. Viscount Astor, Secretary of the Ministry of Health. A special section on Industrial Hygiene, with which Sir Thomas Oliver is associated as one of the Vice-Presidents, will be presided over by Mr. Neville Chamberlain, M.P. Among the subjects to be discussed in this section are Industrial Efficiency and Fatigue, Welfare Work in Factories, and the Health of Seamen.

An attractive programme of visits to local places of interest has been arranged.

RECENT DEVELOPMENTS IN TYPES OF PORTABLE CINEMA OUTFITS

By Captain J. W. BARBER, C.B.E.

(Paper read at the Annual Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, May 11th, 1920.)

I HOPE I may be pardoned for prefacing my remarks on a technical subject by a general reference to the cinema of to-day in relation to its past rapid growth and its future potentialities.

Cinematography has belied the forecast of all but a small number of its early sponsors. A few years only have passed since the great majority of people considered the cinema to be but a passing craze, one that would have a brief and not too bright existence. To-day it is accepted by all as an established institution; but, even now, it is my belief that cinematography is but in the transition stage, which to-morrow will see as an influence wielding gigantic power, and one that will form an integral part in all walks of social and industrial life.

What was yesterday an amusement, supported principally by the lower classes, has become an entertainment welcomed and patronised by all degrees of society, from Royalty downwards, whilst the future will see it in its maturity, so immense that the present entertainment side of the buisness will be probably its smallest part.

"The pen is mightier than the sword"; but the screen of the future will be far mightier than the united press of the world. It may be thought that I am drawing the low bow; but I say this fully conscious of the drastic nature of my statement. I say it because I believe that the cinema forms the missing link of universal intercourse that mankind has been waiting for since the cleavage of the tongues. The cinema is the one universal language requiring no translation for different races, and one, moreover, than can be interpreted alike by all standards of intelligence and degrees of education.

The cinema requires no "reading between the lines"; subtleties of expression are not lost; and, whatever the mental capacity of the observer, the picture tells its story every time precisely as the producer intended.

With these convictions I approach the field of use of portable types of cinema outfits with the belief not that this type of outfit shall be considered an amusing toy of doubtful practicability, but that it should be constructed along lines of the greatest reliability, where precision and simplicity of projection are indispensable conditions.

When manufacturers appreciate the field of work of the future, then great advances will be made; but to-day, when novelty of general appearance and cost of production are paramount necessities for the existing market, it cannot be expected that there exists the type of outfit which the future possibilities of the cinema, outside the walls of the entertainment house, demand.

The cinematograph projector is a combination of optical, mechanical and electrical apparatus, that is, electrical so far as it may be desired to utilise the most convenient form of existing illumination for projection purposes. These three factors are interwoven in the construction of cinema apparatus; and the designer must be one who understands the relative importance and functions of these three primaries. He must, therefore, be optician, mechanician and electrician.

There exist to-day projectors obviously built by mechanics. There are those stamped as it were with the name "optician"; and there is a smaller third where the high quality of the electrical work is only emphasised by neglect of the other two features.

Even in stationary projector work

there is much room for improvement, and we must wait for the future to produce the apparatus that most closely fulfils the requirements of a perfect cinema projector.

At one end of the scale of portability I may perhaps be permitted to place the Cinemotors which I had the honour of devising for His Majesty's Government, and which were used extensively by the Ministry of Information and the National War Aims Committee during the war for work in England and abroad.

Perhaps one should say of this apparatus that it was more mobile than portable, as it was of massive and heavy construction. It consisted of a commercial motor vehicle, on which was carried a pertol-electric generating plant, together with a cinematograph projector and the necessary switchgear, so as to form a self-contained and complete cinematograph apparatus independent of any oxygen or hydrogen, or outside source of electric light for illumination.

The Cinemotors were equipped with spare parts, repair outfits, sleeping accommodation, and portable cooking utensils, to enable each unit to work far removed from its base, and to operate independently of anything except a supply of petrol.

The features of the apparatus were the employment of a very carefully-balanced generating plant, and by the exercise of care in regard to the springs of the motor vehicle, which had to be entirely "unsympathetic" or "out of period" with any inherent vibration of the generating plant.

In this way, and upon the relatively unstable foundation of the motor lorry platform, without the use of jacks or other external appliances, the somewhat delicate cinema apparatus projected a picture as brilliantly perfect and rock steady as that associated with the highest class of cinema theatre.

It has to be observed in this connection that, whereas the distance from the lens to the screen may be anything from 100 to 150 feet, the distance between the lens and the film is but a few inches, so that any oscillation of the projection apparatus around the fulcrum of the light beam would cause a very large displacement of the picture on the screen.

At the other end of the scale of portability I must place the miniature Pathescope, which will be demonstrated this evening, the only other self-contained apparatus, independent of any exterior source of illumination, with which I am acquainted.

Here we have an apparatus weighing but a few pounds, the turning of the projector handle operating the small dynamo generating the current for the incandescent lamp used for projection.

Whereas the Cinemotor had a 5-kilowatt arc lamp illuminating a picture of 500 superficial feet, the Pathescope with its 6-watt lamp projects a picture 4 feet in width, approximating 12 square feet.

Here then we have the two extremes of portable cinema equipments, the one of use only as an appeal to enormous crowds, and the other a useful appliance suitable for an almost infinite number of applications.

A feature of the Pathescope, wherein it departs from all other apparatus at present available, a feature both advantageous and disadvantageous to the user, is that the machine is not standard so far as accommodation to film is concerned, that is, it will run only films specially perforated for the apparatus. The great advantage of this relates to its safety from fire risk, as the makers supply only films of a comparatively non-inflammable character, and which completely eliminate danger of fire. The disadvantage is that the user is limited for subjects to the makers' library, which it must be admitted is fairly comprehensive and in process of enlargement, but nevertheless a possible handicap to many potential users. I understand, however, that an alternative machine to accommodate standard film will soon be available.

In connection with fire, I refer more to the danger incurred during the handling and storing of films, as modern projectors provide safeguards against any serious fire risk during operating.

Nevertheless, a potential danger always exists with inflammable films; and this of course is not lessened, but rather increased, by the use of film equipment in private houses and institutions where the apparatus is within the auditorium, and skilled operatives may not be employed. There are indications which

point to the future discovery of a film base as durable as the ordinary celluloid one now employed, but without the objectionable features of that medium. Still to-day we must face the fact and couple with the possibilities of the cinema its limitations and drawbacks so far as indiscriminate use of film apparatus is concerned.

Between the two already-mentioned extremes, the Cinemotor and the Pathescope, is introduced the great bulk of apparatus classed as home and portable projectors, and which mostly are miniature brethren of the professional model. These, whilst designed to accommodate the standard size of film, are of very light construction and dependent upon an outside source of energy for illumination.

Weight is a consideration in any portable apparatus, but there must be a limit to the cutting down of weight as the essentials of the projection apparatus cannot be eliminated. There must be spools for the holding of the film. A gate must be employed to hold the picture squarely and securely at the correct plane in relation to the optical centre. There must be an intermittent feeding mechanism to bring each successive picture into the line of light precisely in the same position as its predecessor. There must be a shutter so operating that the light rays are prevented from reaching the screen during the movement of the picture, but uncovering for the passage of light immediately the picture has come to rest. There must be a train of gear wheels for operating the principal devices. A chamber must be provided for the light; and a suitable optical condenser and projection lens employed.

These essentials must be present in all projectors; and, moreover, with the exception of the lens and power of illuminant, have no bearing on whether pictures of 2 or 20 feet in width are projected.

Unfortunately, many of the smaller types of what I must designate as miniature professional projectors, owing to the fragility of construction and the poorness of material employed, prevent precision being attained without difficulty, and without frequent adjustment; and it is particularly noticeable that the smaller type of machine is less equipped with accessible adjustments than the larger apparatus, less prone to require it.

The last year or so has, however, seen the introduction of a type of apparatus which has met a big demand for a machine portable in character; and, whilst being particularly light, is nevertheless built on sound lines, the component parts being correctly proportioned and made of high-grade metals.

The source of illumination is usually a half-watt focus type incandescent lamp, the energy being obtained from the ordinary domestic service. The whole is mounted in a travelling case; and I think I can refer collectively to this type of apparatus as the "Suit Case Projector."

Whilst this does not meet every demand of the future, the type nevertheless presents a highly useful projection appliance. The whole is self-contained, requiring no dismantling and re-erection, except of course the screen, which is a separate unit, and can be hung anywhere. It is practically vibrationless, requires no special stand, and can be operated from any table.

I am able to show you this evening two makes of this class of projector, each fitted with a miniature driving motor, so that, after the threading of the film, nothing is needed but to close the switch and let the machine do the rest.

It is astonishing the service this light type of apparatus will perform with suitable screens and an ordinary 5-ampere supply. A good 6 or 7 feet wide picture can be projected that will satisfy most ordinary purposes.

I have recently seen, and I am fortunate to have loaned me this evening, the only apparatus of the kind in this country. The outfit, although not strictly portable, is one possessing extraordinarily unique features, and should fill a want for houses and institutions where a small cinematograph apparatus is desired for permanent use. The machine is designed in cabinet form, and a translucent screen employed, the light being projected via a series of mirrors on to the back of the screen. In this way little space is occupied, as the greatest length of the cone of light is in a vertical direction.

I am of opinion that there is con-

siderable room for mechanical improvement in this apparatus ; but it certainly is an outfit possessing outstanding and novel features, and seems to be the ideal for chamber use. It is not possible to stand in the way of the light. It is not necessary to hang the screen on the opposite wall. The whole plant is always there unobtrusively, as the outfit, as will be seen, can be built to represent a book case, or similar piece of furniture, and made to harmonise with its surroundings. It is ready at a moment's notice to produce a picture.

My remarks will not be complete without a few notes on the ideals to be aimed at in the manufacture of the portable or home type of projector.

Fire Risk.

First and foremost comes safety from fire. To ensure the greatest degree of protection the apparatus, whatever its general shape, must be compartmented. Each spool of film should be in a separate metal magazine with film passages therefrom, so fitted with traps that, in the event of fracture of the film, or ignition by fire in its passage across the line of light, the apertures become securely sealed, and the fire prevented from reaching the bulk of the film.

The lamp, particularly when a half-watt lamp of high candle-power is employed, should be in an effectively ventilated chamber; and, if the optical condenser be not fitted direct to this chamber, then a piece of suitable optical glass should be fitted in the light aperture to prevent the heated air freely circulating into the general mechanism.

Intermittent Movement.

The intermittent device is rightly the heart of the projector. This mechanism has to operate the film in successive movements at the rate of 16 to 20 per second. The sine wave of movement of the film differs with the varying mechanical devices employed ; but practice has shown that the maltese cross or Geneva star movement is the best all-round one for the purpose. This device starts the film from rest at a very slow rate, increasing in velocity to the middle of its travel, and gradually and slowly bringing the film to rest, after which, by the position of the cam on the face of the cross, the device is securely locked until the next movement. There is with this mechanism less wear and tear on the delicate fabric of the film; and the locking device tends to prevent over-running of the film through the gate, and so enables less pressure to be applied to the aperture plate.

The whole of this mechanism should be, irrespective of the general dimensions of the apparatus, of substantial construction, and made only of the highest grade steel.

The Film Gate.

The gate through which the film passes, one plate of which is fitted with pressure springs, or parts operated by springs, should be long, at least four times the height of the picture, the longer the better, as the pressure necessary completely to arrest the film and hold it securely and squarely across the plane of the light is then distributed throughout a greater length of film. Too much thought is not always given to this important factor ; and, for that reason, big pressures are frequently applied to short lengths of film with consequential greater strain to its emulsion and base.

The Shutter.

The three-blade shutter is generally accepted as the type most free from producing flicker; but, in point of fact, tests have convinced me that the number of segments with which a shutter be fitted is not of great moment if the alternating periods of light and dark are in every case equal. Unless this is attained, and there are few projectors where the shutters have such equal divisions, flicker exists to some degree, being aggravated in subjects predominating in high lights, and when the speed of projection is kept low.

Optical.

The optical appliances must be of the highest grade, as by reason of the present limitation of the unit of light available, there is no margin for waste. Moreover, owing to the close proximity from which pictures are usually viewed with this type of apparatus, the objective should give a clearly defined image free from

the aberrations inseparable from any but the best combinations of lenses and qualities of glass. In this connection I can tell you that professional outfits, the projection mechanisms alone costing perhaps £100, are sometimes fitted with lenses retailing at 10s. each. It is the lens that makes the picture; and, unless a high grade one be employed, the results may be painful and disappointing.

Purchasers of any apparatus therefore should always specify for a lens of high repute.

These are the principal points to be observed to ensure the highest degree of projection; and I trust that those who have loaned me apparatus for demonstration will not consider my remarks to be other than the views I hold on what I consider to be the ideals which should be aimed at in the construction of any cinematograph projector. Their different outfits have reached a complimentarily high standard of perfection. I am personally interested in no make of apparatus, and view things only as a user of existing appliances; as an enthusiast in projection matters; and as a firm believer in the immensity of the future of the cinema industry, fully conscious, however, of the responsibility it holds to all those who view pictures, both in private and public.

The portable projector is here, and has come to stay, and will be an important factor in popularising cinematograph pictures, not only in the home, but in the immense and hitherto untapped field of education.

I need hardly enlarge upon this most important field, which must be quite obvious to everyone present. Educational bodies throughout the country are becoming increasingly alive to the value of the cinema in lightening their labours, and in bringing education to the masses.

As one may suppose, the professions are looking with interest upon the cinema projector; and I believe that its use will become prevalent in hospitals and other scientific institutions.

For instance, in a hospital or research laboratory, a microscope shows to the student some object hidden from the naked eye. If a cinematograph film dealing with microscopic work be prepared, the cinema projector will enable the demonstrator to show those objects to a class of many students, which formerly each one had separately to observe by means of a microscope.

Again, in general education, what agency can be employed to teach our children so readily and so effectively as the cinema? In kindergarten, in university, and through all ages of adult life, whatever part the cinema is playing to-day is minute as compared with what it will play, I feel sure, in the early future.

Unfortunately, it has not been appreciated in the past that cinematography from beginning to end involves illuminating engineering problems. From the initial photographing of the picture and the impinging of light rays on the photographic base, right up to the projection of the resultant picture on the screen, daylight, artificial light, or a combination of both are employed for the different processes.

It is my hope that the members of the Illuminating Engineering Society will appreciate the importance of the art of cinematography, and will realise its big field of operations, and may help individually or collectively to improve conditions, both in the studio and in the projection room.

The co-operation of illuminating engineers will enable better studio photographic work to be attained; and, on the other hand, by research in the production of better and more efficient projection lamps; by the investigation of the reflective properties of different screen materials; by consideration of the relative illuminations of the screen and the room in which the screen be fixed, the art of cinematography will be brought a considerable stage nearer to the perfection of results which the potentialities of this great art justify.

In conclusion, I wish to tender my thanks to those who have so kindly loaned apparatus for demonstration here this evening. I am indebted to:—

Sir William Jury for the use of the Acme Portable Projector;

Mr. George Palmer for his De Vry Projector;

The Pathescope Company for their apparatus; and

Mr. William Dederich for the use of the Petra Cabinet.

RECENT DEVELOPMENTS IN TYPES OF PORTABLE CINEMA OUTFITS.

(*DISCUSSION.*)

THE CHAIRMAN (Dr. James Kerr) said that the demonstration of portable cinema apparatus had been extremely interesting. It marked, as the author said, the beginning of new conditions. Hitherto people who wished to see moving pictures had been obliged to betake themselves to a hall more or less distant from their house, but it looked as though in the future they would be able to do a good deal in the quietness of their own home, studio, or workroom. There could be no doubt that a portable cinema, which met all requirements as regards safety from fire, had great possibilities, and doubtless the noise, more or less inevitable with such machines at present, would be diminished before long.

The little pathescope had shown them how, with a slow speed, movements could be analysed and demonstrated in a remarkable way, and the apparatus had thus a considerable educational value in explaining movements. It was curious that although work had been done on the subject for twenty years or more, the nature of the motions of the eye, on which there had been much experimental observation with an extensive literature, not only in observing cinema pictures but in reading, were not yet completely understood, and it was only recently that the key to this problem had been obtained. The matter could have been settled much more readily by a few weeks' observation, had a small laboratory cinema apparatus been available for their analysis.

Portable cinema outfits might thus be expected to form an important adjunct to the laboratory, and for school use their possibilities were great. He was inclined to think that in this field also the future prospects lay more in the direction of imitating and reproducing movements, as in dances and physical exercises, than in the presentation of historical scenes or in teaching by photography.

Safety against fire, in this connection, was naturally a consideration of great importance. Several of those present, notably Major Cooper-Key of the Home Office, and Mr. Ridley, who dealt with such matters for the London County Council, would doubtless be able to make some suggestions on this point; while Mr. Goodwin who, like Mr. Ridley, had been helping on the Committee of the Society studying conditions in cinema theatres, would no doubt be able to tell them something regarding the supply of films for domestic and educational use.

The apparatus shown differed in several respects. The pathescope was completely independent of any external supply of electricity, while the other forms only required the supply suitable for incandescent electric lamps. The cabinet form was a most ingenious and interesting form of portable cinema, and he was especially struck by the subjective impression produced as of looking through a window at some scene outside.

Mr. F. R. GOODWIN, C.B.E. (President of the Cinematograph Exhibitors Association), congratulated the author on his paper and on the demonstrations, and the Illuminating Engineering Society on the facilities afforded to him. He was somewhat surprised that the "Franco" projector had not been mentioned. This apparatus came prominently before his notice just before the close of the war. It utilised a very small bulb glowlamp supplied from a 6-volt motor-car battery, and an excellent picture was obtained. The apparatus was driven by hand, and was in some respects superior to many forms of portable apparatus available, being strong and very simple in construction.

As regards the question of safety from fire, he fully recognised that this was a matter that demanded care in the use of films for educational purposes, and the trade would welcome any further suggestions and advice from the Home Office on this point.

Major A. COOPER-KEY (Chief Inspector of Explosives, Home Office) said he was very much interested in the small portable machines shown by Captain Barber, which he had not had an opportunity of

inspecting previously. They seemed now to have reached a promising stage, and he thought that they had come to stay.

Several speakers had referred to the matter of safety, and the Home Office were at present interested in the problem of using films of a non-inflammable nature. He understood that the chief difficulty up to the present time was that this type of film would not stand wear and tear. He felt sure that if a satisfactory non-inflammable film could be introduced the Home Office would give it every encouragement.

Mr. E. RIDLEY (London Fire Brigade) agreed that Captain Barber's demonstrations showed that the portable cinema outfit is now a practicable thing. The fire-risk lay in the use of celluloid film, and owing to its ribbon form and to the particular kind of celluloid used, this would ignite very easily. The point to be noted in connection with portable cinemas was that such apparatus would probably be used by inexperienced people, including the sort of person who would act on the advice, "if your film is dull, warm it in front of a fire for a few minutes!" He believed that old worn-out films could be purchased at a price less than the value of new celluloid, and such films could be bought in many small shops in London. Several fatal fires had occurred through children and others buying such films and putting them through toy machines, and if the use of portable machines became popular there would be a danger of more fires, not necessarily in the machines, but due to careless handling or storage of the films in the proximity of a light or an open grate.

From the safety standpoint what was needed was a film not composed of celluloid. According to his information, which he thought would be confirmed by the author, the non-inflammable substitutes did not wear so well as celluloid, besides being more difficult to obtain. The present legislation appeared to prohibit the projection of celluloid films elsewhere than in a private house. If the Home Office adhered to their definition of "inflammable" films, the production of films of the non-inflammable variety would probably be encouraged, but there would remain the risk due to the inadvertent use of celluloid film.

Mr. J. C. ELVY expressed his appreciation of Captain Barker's paper, and especially his statement of the opportunities for co-operation between the cinema expert and the illuminating engineer.

He (Mr. Elvy) was interested chiefly in the production of the actual film, and in this field there were quite as many opportunities for such co-operation as in the projector side of the business. Most of the pictures shown that night had been taken in America, where daylight conditions were much less variable than in this country. Accordingly the design of the artificial lighting of a studio was of great importance. He was engaged in equipping such a studio in a spot well outside the "fog zone," and it appeared to him that there was much still to be settled regarding the nature of the lights to be used. Fuller information was needed on the relative actinic value of various sources, and on the best means of diffusing light so as to produce agreeable shadows and avoid extreme glare in the eyes of the actors. Mr. Elvy quoted some data on these points that had previously been referred to in THE ILLUMINATING ENGINEER. It would be very valuable if the merits of the various available lighting units, special arcs, mercury vapour lamps, gas-filled lamps, etc., could be thoroughly tested under a competent authority, and he suggested that a Sub-Committee, on which the Royal Photographic Society should be represented, might be appointed by the Society. One task for such a Committee would be to devise a suitable instrument for testing actinic values.

Mr. A. BLOK said that it was a remarkable achievement for one to be able to sit in a room in one's own house and to see the restlessness of the waves, the massive impassivity of a mountain peak or a scene in the remote west of the United States. One realised that with the advent of the portable cinema a most valuable educational tool had made its appearance. There were many opportunities in schools and the like for the use of such apparatus. It should be of

the utmost value in dealing with natural history, and in illustrating the production of economic commodities, industrial and technical processes, and biological phenomena. With care and skill in the preparation of the films all these things could be made accessible for educational work in a manner not possible by ordinary methods.

There were, however, two factors which determined the usefulness of the cinema in this field. The primary factor was that unless the apparatus was good it could not live. This, no doubt, would be solved by the natural competition between various forms of apparatus. The other factor was the question of cost. In equipping an educational establishment this was always a crucial point, and unfortunately we were still at a stage when education was being starved. If Captain Barber could give an indication of the probable cost of the bioscope, the "suit-case" apparatus, and the cabinet type, this would be useful.

He hoped that it would not be regarded as lack of appreciation on his part if he referred to the inadequate nature of the screens used in some of the exhibitions at the meeting. One fault was a curious horizontal striation which interfered with the appearance of the picture, and in the large aluminium screen shown there was also considerable specular reflection. The creases in the top left-hand corner of this screen showed, when viewed from the centre of the hall, a dark zone which spoiled some of the cloud-effects. This showed the drawback of using a screen, which was not tightly stretched or which had not a rigid background, so that folds and creases could not occur. The screen used in the cabinet form of apparatus was, he thought, the most satisfactory, and the production of this little picture was a matter for the utmost congratulation of the manufacturers of the apparatus. The production of a satisfactory screen was almost as important as the design of the optical system, which Captain Barber had explained so fully.

Mr. A. L. ROBERTS (Architect to the Hampshire County Council), said that, as an officer dealing with the inspection of buildings for which licenses were sought under the Cinematograph Act, he would like to endorse the importance of two points referred to in the course of the discussion, the development of the non-inflammable film, and the possibility of fires arising through the operation of portable cinema outfits in inexperienced hands.

No doubt when the present regulations were framed portable cinema outfits were not thought of. A curious point arose in connection with companies which toured the country with a portable outfit, going from village to village, and giving one show in each place each week. It was argued that in such cases the building was only used for one night a week, and that this did not constitute habitual use of a building. Accordingly the point arose whether the cinema apparatus must be in a special enclosure or whether it might be placed in the auditorium. Such difficulties would be greatly simplified if a suitable non-inflammable film could be used, especially in view of the fact that many of the buildings selected for these occasional shows were schools, etc., which were not devised with a view to cinema exhibitions, but might be increasingly used for such purposes in the future. He was constantly inspecting such buildings, and in one recent case he found that an inflammable film was being used in a hall where there were more than a hundred people, some of whom were sitting close to the machine (which had no enclosure nor spool box), and smoking and striking matches. The use of non-inflammable films would relieve authorities of much anxiety in dealing with cases of this kind.

Mr. LEON GASTER, in moving a vote of thanks to Captain Barber and those who had contributed to the interest of the evening by exhibiting apparatus, said that he regarded it as a special privilege to have had the opportunity of seeing this apparatus in action, some, he understood, exhibited for the first time in this country. It had also been a pleasure to profit by the experience of Major Cooper-Key and Mr. Ridley, and he felt sure that the precautions they suggested, with a view to preventing possible accidents, would be carefully borne in mind.

Mr. J. S. Dow (*communicated*): I should like to endorse Mr. Blok's remarks on the importance of the screen. Tables have been presented by various authorities in the past comparing the brightness attainable at various angles of view with dead-white and aluminium coated screens. Naturally wide variations are recorded according to the nature of the latter surfaces, but in general I question whether an aluminium surface is desirable, except in very narrow rooms. The loss of brightness experienced by people who view the picture obliquely has to be very carefully considered; there is sometimes inconvenient specular reflection, and folds or creases in the surface of the screen seem to have a greater effect than when dead-white material is used. In any case the screen should be attached to a rigid background and not merely suspended.

In the apparatus shown by Captain Barber the problem of securing a sufficiently bright picture has been met with very fair success, especially in the case of the small screen used with the cabinet form. But I believe that there is still great scope for improvement in the joint design of the light source and projecting apparatus. I think it would be found that in most cinema halls the amount of light actually used in the picture is still less than 1 per cent. of that produced at the source. When a filament is used as the source the optical difficulties are accentuated, and in the United States special types of gas-filled lamps (used in conjunction with appropriately designed "semaphore" condenser-lenses which enable an exceptionally large proportion of the total flux of light to be dealt with), are said to have given excellent results, even competing with an arc of moderate power. It would appear that there is still much to be done in this way in portable cinema outfits, where the production of an image bright enough to be seen with the ordinary lighting of a room maintained, or even in daylight, does not seem to present insuperable difficulties.

Captain J. W. Barber, C.B.E., replying to the discussion, said he fully appreciated the need for taking precautions against danger from fire, because the success of the cinema industry depended on retaining the confidence of the public. The entire industry agreed that provision must be made to prevent fires occurring, and serious opinion in the trade welcomed suggestions from the authorities in this direction.

In regard to non-inflammable films, he said that it was, in fact, the case that these films possessed very short working life, and were, therefore, not encouraged.

He thought, however, that in this connection Major Cooper-Key could, perhaps, help the industry. It had not been clearly defined what was an inflammable or non-inflammable film; but if a lead were given as to what constitutes inflammability, he thought that the trade would put up money for the purpose, and their chemists would make investigations.

Unfortunately, at that moment, the authorities, when asked to test a film, applied a match, and if there was ever any suggestion of singeing or slight burning, the substance was not passed as non-inflammable. Now it was never hoped that any material could be produced that was entirely non-inflammable—and after all inflammability was a question of degree; but if some consideration was shown to the users of a comparatively non-inflammable base, then the trade would not be long in discovering the material.

He, therefore, suggested that the Home Office should give the trade some guidance and establish some standard of inflammability, which they would pass for exhibition under conditions differing somewhat from those imposed where ordinary highly inflammable celluloid—for which in fact the Act was framed—was used.

As things are at present, it was not much encouragement to the trade to find that after the expense of considerable time and money in the production of what is, to all intents and purposes, a non-inflammable film, no consideration be given to its user, who is subject to the same conditions regarding its exhibition as if he were employing the most highly combustible nitro-cellulose material.

In regard to Mr. Elvy's remarks on the illumination of studios, he said that

he had not referred to this matter, as it was somewhat outside the scope of the paper. It was, however, a fact that the sensitised film base was not affected to any extent by the red end of the spectrum. If any white light were employed all except the ultra-violet rays were wasted. They had mercury vapour lamps and also high voltage arc lamps, designed to give a preponderance of ultra-violet rays. Both had their advantages and disadvantages, and were necessary adjuncts of any studio. However, there was much room for improvement; and he thought that illuminating engineers, if they realised that cinematography was a powerful factor that had come to stay, would devote some time and thought to effecting an advancement in lighting work.

With regard to the approximate cost of apparatus, the suitcase outfits cost between £50 and £60 and the pathescope 30 guineas. The cost of the cabinet apparatus would depend largely on the type of cabinet work used. This form was necessarily more expensive, but should fill a great want.

In reference to the remarks of Mr. Roberts regarding touring companies, it is not expected that these should drop into a hall and give an exhibition without notifying the authorities, who should ensure that everything was satisfactory. In imposing restrictions with regard to this class of exhibitions, the authorities would naturally be guided by the nature of the apparatus used; but he thought that when the apparatus was enclosed in an iron box, the existing regulations might be relaxed more liberally, especially in regard to the number of exits.

Captain Barber brought a valuable and instructive evening to a close, with an assurance to those officials who were responsible for the safety of the public, that the Trade intended to avail itself of no loophole in any Act, but would loyally observe, in the spirit as well as the letter, any safeguards that might be imposed.

TEACHING CITIZENSHIP BY THE CINEMA.

A special report (No. 4) on " Visualising Citizenship " prepared by Ina Clement and issued by the Municipal Reference Library of New York, contains an instructive account of methods of teaching civic duties by means of cinema displays. Local authorities frequently make use of the film to educate public opinion regarding some new project or legislation, (*e.g.*, municipal ownership of railways, endowment of recreation grounds, town planning, etc.). Churches and welfare organisations likewise arrange demonstrations dealing with points of conduct or health. In the schools of New York cinema displays are being arranged as an aid to courses in geography, biology, etc.

A most important point is the creation of " Film Libraries." Already some comprehensive lists exist such as those prepared by the National Board of Review of Motion Pictures. A film foundation to organise such libraries on a large scale is now proposed. The foundation would work in co-operation with existing government departments and other organisations.

A number of agencies interested in educational films are mentioned, and the report is concluded by a varied list of subjects available, including " Safety Measures," " Child Welfare," " City Planning," " Education," " Health and Hygiene," etc. This report should be of great interest to those concerned with cinema productions in this country.

INTERIM REPORT OF THE JOINT COMMITTEE APPOINTED BY THE ILLUMINATING ENGINEERING SOCIETY TO INQUIRE INTO "EYESTRAIN IN CINEMAS."

June, 1920.

Origin of Committee. The Committee was formed in response to a request conveyed to the Illuminating Engineering Society in a letter from the London County Council dated April 28th, 1919 (No. 6142), asking for information in regard to the possible causes of eyestrain in cinemas, and the best means of removing them, and in particular " the question of the strain on the eyes caused by the proximity of seats to the screen at cinematograph halls, and of the possibility of devising some means of lessening the ill-effects referred to."

Constitution of the Committee. Following the receipt of the letter referred to the Hon. Secretary had various conversations with officials of the L.C.C., and placed at their disposal the information available from previous discussions before the Society and other sources. But it was felt that in view of the importance of the inquiry, both to the public and the cinema industry, it could best be conducted through the medium of a thoroughly representative joint committee, whose findings would carry weight.

The following Joint Committee was accordingly constituted :—

(*a*) Representing the *Council of British Ophthalmologists :* Mr. Bernard Cridland, Mr. Stephen Mayou, Mr. W. H. McMullen, Mr. J. Herbert Parsons, C.B.E. (Chairman).

(*b*) Representing the *Cinema Industry:* Captain J. W. Barber, C.B.E. (Member of the General Executive Council of the Cinematograph Exhibitors' Association of Great Britain and Ireland), Mr. F. R. Goodwin, C.B.E. (President of the Cinematograph Exhibitors' Association of Great Britain and Ireland), Mr. A. E. Newbould, M.P. (Past-President of the Cinematograph Exhibitors' Association of Great Britain and Ireland, and Member of the General Executive Council of the Association).

(*c*) Representing the *Illuminating Engineering Society :* Mr. A. Blok, Asst.-Prof. W. C. Clinton, Mr. J. S. Dow, Mr. L. Gaster (Secretary), Mr. F. W. Goodenough, Mr. Haydn T. Harrison, Prof. J. T. McGregor-Morris.

(*d*) Dr. James Kerr (Medical Research Officer, Public Health Dept., L.C.C.), Dr. C. W. Kimmins (Chief Inspector, Education Dept., L.C.C.), Mr. E. Ridley (Inspection Dept., London Fire Brigade, L.C.C.).

(*e*) Representing the *Physiological Society:* Prof. W. M. Bayliss, F.R.S., Prof. C S. Sherrington, F.R.S., Prof. C. Spearman.

Nature of Work. The first meeting of the Committee was held on October 28th, when a memorandum summarising the chief problems falling within the terms of reference of the Committee was presented, the various matters being arranged in order of urgency and importance. In order to facilitate work questions were distributed amongst four sub-committees, namely, the Physiological Sub-committee, the Physical Sub-committee, the Trade and Control Sub-committee, and a General Purposes Sub-committee, by whom reports could be presented at meetings of the General Committee. On each of these sub-committees one member from the various other committees was appointed, with a view to obviating overlapping of work and enabling interchange of views to take place. In view of the fact that the Committee was composed of experts in their respective fields it was not thought necessary at this stage in the proceedings to invite outside evidence.

In addition to meetings for purposes of discussion a number of experimental demonstrations have been witnessed, and a number of typical cinema halls visited by members of committees, while additional data relating to other halls have been tabulated for comparison.

The Committee are now in a position to formulate certain conclusions, whilst on other matters tentative suggestions are made.

RECOMMENDATIONS AND SUGGESTIONS.

Limit to Vertical Angle of View (*Angle of Elevation*).—In considering the question of close proximity of seats to the screen the Committee have formed the opinion that the ocular discomfort arising is due mainly to the fact that the eyes of spectators are directed upwards at an abnormal angle, a condition which is conducive to eye-fatigue and liable to give rise to headache and general discomfort; whereas the direction of the eyes horizontally or downwards appears natural and agreeable. The condition of discomfort referred to is not determined solely by the proximity of the front row of seats to the screen and the vertical measurement of the picture. Another important circumstance is the height above the observer's eye-level at which the picture as a whole is viewed. It would therefore not suffice to specify a minimum distance of seats from the screen, nor even a certain ratio between this distance and the vertical measurement of the picture. The requirement should include all the three factors enumerated above, but should be of a simple and definite character, capable of easy application.

The Committee, in determining such a requirement, have been guided partly by the knowledge of the physiological and ophthalmological experts on conditions liable to cause discomfort and fatigue to vision, and also on the experience of all the members of the Committee, when visiting a number of cinema halls in the London district. In each case the pictures were viewed successively from various rows of seats, the positions from which discomfort and eye-strain were experienced noted, and the corresponding angles of elevation recorded. In framing a general recommendation based on these experiences due account was taken of such variable factors as the proportion of screen occupied by the picture and the extent to which the eye is directed respectively to the upper, central and lower areas of the screen, with the ordinary available seating accommodation.

In some of the cinema halls visited the conditions were found to be such as are likely to cause visual discomfort and eye-strain. By comparing the record of their experience in this respect with the tabular data summarising the angles of elevation in the various cinemas visited, the Committee came to the conclusion that it would be possible to secure conditions suitable for the eyes, and to materially diminish the possibility of eye-strain if a moderate value for the angle of elevation were adopted. It appeared that the desired conditions could be suitably expressed by stating that the angle of elevation, conveniently

measured from the top of the picture as defined below, should not exceed 35°—a simple and easily interpreted recommendation which is to be regarded as embodying all the various factors mentioned above.

The Committee accordingly make the following recommendation :—

(I.) That the angle of elevation, subtended at the eye of any person seated in the front row, by the length of the vertical line dropped from the centre of the top edge of the picture to the horizontal plane passing through the observer's eye shall not exceed 35°, the height of the eye above the floor-level being assumed to be 3 ft. 6 in.

Investigations have shown that in some cinema halls in London this condition is complied with, while in others it is approached. In other cases the angle of elevation exceeds 60°—a condition that is clearly prejudicial and could be removed by eliminating some of the seats in the front rows. It should be noted that in such cases it may not be necessary to eliminate a complete row of seats, as in the seats nearer the sides of the hall the angle of elevation is less than in those immediately facing the screen, and may fall within the prescribed value of 35°. The most favourable condition is thus to arrange the seats in an arc of a circle, the concave edge of which faces the screen—an arrangement already adopted in some modern cinema halls.

The limiting circle, corresponding with an angle of elevation of 35°, will have as its centre the intersection of a vertical line from the centre of the top of the screen with the horizontal plane at eye-level (3 ft. 6 in. above floor); and as its radius a distance equal to 1·43 (*i.e.*, rather less than one-and-a-half) times the height of the top of the picture above eye-level.

Limit to Lateral Angle of View.—Assuming that the above recommendation (*i.e.*, that the Angle of Elevation should not exceed 35°) is complied with, the effect of viewing the screen at an unduly oblique angle from side seats requires to be considered. While this condition is productive of inconvenience and constitutes a possible source of eye-strain, it appears to be of less importance than the avoidance of unduly great angle of elevation.

The Committee accordingly make the following recommendation, which has been framed to apply equally to cases where vertical or inclined screens are used :—

(II.) That provided Recommendation (I.) is complied with, the angle between the vertical plane containing the upper edge of the picture, and the vertical plane containing the observer's eye and the remote end of the upper edge of the picture should not be less than 25°.

Minimum Distance of Seats from Screen.—The Committee has had under consideration the question of undue proximity to the screen as a source of difficulty in following movements in the picture, leading to possible eyestrain. While conscious that undue proximity to the screen impairs the ease with which pictures can be examined, the Committee are of opinion that compliance with Requirements (I.) and (II.) renders further recommendations in regard to such distance unnecessary at present.

Maximum Distance of Seats from Screen.—It is clear that a limit to the distance of observation beyond which it is difficult to distinguish pictures satisfactorily, exists, although managers of halls will usually ensure, in their own interest, that this limit is not exceeded. It has been suggested that the angle subtended at the eye by the height of the screen, viewed from the most remote seat, should not be less than 5°, or, alternatively, that the distance of the most remote seat should not exceed twelve times the height of the picture. The Committee, however, require further evidence before making recommendations on this point, and in the data at present collected, no case has been noted in which the above suggested limit has been exceeded.

Flicker.—There are several phenomena which are included in the common use of the term flicker, and have been the subject of investigation by the Committee.

The two most important for our purpose are :—

(A) *Physiological Flicker.*—This occurs when light and dark are alternated. It disappears at a certain critical rate of alternation, which rate depends upon the brightness of the illumination. It is most noticeable with the periphery of the retina so that on a large screen it may be absent from the part of the screen directly looked at, though the observer is conscious of the flicker on the outlying parts of the screen. Under normal conditions of projection no appreciable physiological flicker is observable in the pictures unless there is a large expanse of brightly illuminated screen (*e.g.*, sky or snow field).

(B) *Disintegration Flicker.*—The pictures shown on the screen are composed of a series of rapidly succeeding pictures which are integrated physiologically and should give the impression of continuous movement. Under certain conditions, *e.g.*, figures moving rapidly in the foreground, especially from side to side, the separate impressions become perceptible—an effect which is most noticeable near the screen, but is frequently visible from all parts of the hall. It is possible that the effect might be minimised by taking more pictures per second and projecting at a correspondingly increased rate, but this presents technical difficulties.

Of all the disturbing factors manifesting themselves by jerkiness of movement, disintegration flicker is undoubtedly the most serious.

Film and Mechanical Defects.—The Committee have devoted attention to various irregularities arising from defects in films or apparatus. Scratches on old films give rise to an appearance of vertical black lines like rain. Holes in the gelatine cause flecks of light. Worn sprocket holes, and mechanical defects arising from instability of apparatus may give rise to disturbing effects. Various promising improvements in projecting apparatus and screens have been brought before the Committee.

While the elimination of imperfect apparatus and films, and faulty operation, such as may occur in halls in the poorer districts, is much to be desired, the Committee do not at present see their way to recommend a definite criterion by which to condemn the exhibition at any particular theatre.

Brightness of Screen.—The Committee have made a series of measurements of the brightness of screens while pictures are being shown. Here, again, faulty apparatus, involving inadequate screen-brightness, undoubtedly increases the difficulty of following pictures. The observations of the Committee suggest that a possible standard of minimum brightness may eventually be given, but their researches on this point are as yet incomplete, bearing in view the great variations in light required with different subjects, films of different density and different types of screens.

Portable Cinema Outfits for Schools.—The Committee have witnessed some demonstrations of the use of portable cinema outfits for schools, a type of device which appears to be in the experimental stage but has promising possibilities, and in view of the growing demand for apparatus of this type improvements may be anticipated in the near future.

As an educational medium the cinema has possibilities, but in view of the fact of its being intended for display before young children, the conditions of use for exhibitions in schools require careful consideration. One difficulty at present is to obtain a portable source of sufficient brightness which can be obtained from the electric lighting supply usually available. In order to render the picture sufficiently visible it is necessary to darken the schoolroom by the use of blinds, and it would be advantageous to have the screen recessed and surrounded by a narrow curtain, with a view to further protection of the screen from extraneous light.

In order to secure additional brightness, semi-polished aluminium screens are sometimes used. In this way the brightness, to observers immediately facing the screen, is much increased, but the brightness as seen from side seats is seriously diminished. From the experiments conducted by the Committee they are disposed to prefer a dead white screen for general use and recommend that aluminium screens should only be used in exceptionally long and narrow rooms,

where the angle of lateral view does not become unduly oblique.

Another point to be considered is the method of fixing the projecting apparatus, which, owing to its lightness, is apt to vibrate, causing unsteadiness in the picture.

Inflammability of films as a possible source of danger of fire demands special precautions in such cases, but this is not a matter falling within the terms of reference of the Committee.

Conditions of Artificial Illumination in Theatres.—In accordance with the Council's recent requirement a minimum standard of illumination is now generally maintained in theatres whilst the pictures are being shown. From the observations already made in cinema halls the Committee are satisfied that the requirement that the illumination in all parts of the theatre should not be less than 1-40th of a foot-candle can be readily satisfied without prejudice to the picture. Indeed there seems no doubt that by using suitable methods of distributing the light this illumination might be somewhat increased without interfering with the display of the pictures. A practice that might well be encouraged when the design of the lighting of halls is under consideration is the gradual diminution of the intensity of illumination, passing from the rear of the theatre (where illumination is chiefly needed to facilitate the work of the attendants), to the seats near the screen where stray light is most apt to affect the picture on the screen (and where such illumination is less needed because the seats are to some extent illuminated by light reflected from the screen). This practice would also be advantageous in facilitating the accommodation of the eyes of persons, passing from the bright light outside into the relatively dark interior of the hall. Recommendations in regard to arrangements of light with a view to conforming with the requirements of vision as regards absence of excessive contrast and glare are also in contemplation. Meantime the Committee would suggest as a definite rule, already observed in the best cinema halls, that no unscreened source of light should be visible to the observer in any seat in the theatre whilst looking towards the picture.

CONCLUSION.

In conclusion the Committee desire to draw attention to Recommendation (I.) relating to the Angle of Elevation, and Recommendation (II.) relating to the Lateral Angle of View, as embodying conditions which appear desirable in cinema halls. The Committee do not anticipate that any supplementary recommendations which they may submit as a result of their further inquiries will necessitate any modification of the two recommendations now submitted.

Signed :—

(*a*) J. HERBERT PARSONS (*Chairman*).
(*c*) L. GASTER (*Secretary*).
(*b*) JAMES W. BARBER.*
(*e*) W. M. BAYLISS.
(*c*) A. BLOK.
(*c*) W. C. CLINTON.
(*a*) B. CRIDLAND.
(*c*) J. S. DOW.
(*c*) F. W. GOODENOUGH.
(*b*) F. R. GOODWIN.*
(*c*) HAYDN T. HARRISON.
(*d*) JAMES KERR.
(*d*) C. W. KIMMINS.
(*a*) S. MAYOU.
(*c*) J. T. MCGREGOR MORRIS.
(*a*) W. H. MCMULLEN.
(*b*) A. E. NEWBOULD.*
(*d*) E. RIDLEY.
(*e*) C. S. SHERRINGTON.
(*e*) C. SPEARMAN.

* *Reservation.*—The three representatives of the Cinema Industry sitting on the Committee, whilst approving Recommendation No. I. of this Report as an ideal one which will add greatly to the comfort of the public, draw attention to the absence of definite evidence of serious injury by eyestrain. In view of this fact they are of the opinion that where application of this condition to existing halls would entail serious financial hardship there is no justification for its imposition. They are further of opinion that the normal development of the cinema theatre will rapidly remove all causes of possible discomfort.

Signed :—

JAMES W. BARBER. (*b*)
F. R. GOODWIN (*b*)
A. E. NEWBOULD. (*b*)

C

PROJECTION SCREENS FOR CINEMA WORK.

The Transactions of the Optical Society contain an account of a paper read on the above subject by Mr. C. W. Gamble (of the Dept. of Photographic Technology, College of Technology, Manchester) on October 16th, 1919. It is remarked that the importance of the screen in cinema work is usually insufficiently appreciated, and some of the worst examples of projecting screens are to be found in the rooms of colleges devoted to the teaching of science. Two obvious requirements are that the screen should be *flat* and *smooth*, and if possible without a pronounced "grain." The author summarises his impressions of seven different types of screens, the most pleasing effect being obtained from a screen coated with white Duresco preparation. Aluminium-painted surfaces gave a brighter image, but the necessity for limiting the angle of view with this form of screen should be borne in mind. Also when the reflective power of the metallic screen is high the glare due to lack of perfect diffusivity may cause considerable visual discomfort. Most screens deteriorate in use, owing to deposits of dust or ageing of material, which materially reduce the brightness of the image. Frequent cleaning or renewal of the surface is therefore necessary.

Dr. Nutting, in a paper on this subject,* has suggested that the ideal screen should reflect all light thrown upon it uniformly over an angle of 30°. He proposes three quantities as defining the effectiveness of a screen: the *Reflecting Power*, i.e., the percentage of the light striking the screen which is reflected; the *Diffusive Efficiency*, i.e., the percentage of the light reflected from the screen, which is emitted with an angle of 30°; and the *Total Efficiency*, a combination of the above two quantities, i.e., the percentage of the light striking the screen which is reflected within the angle of 30° specified above.

The following data were presented for different forms of surfaces :—

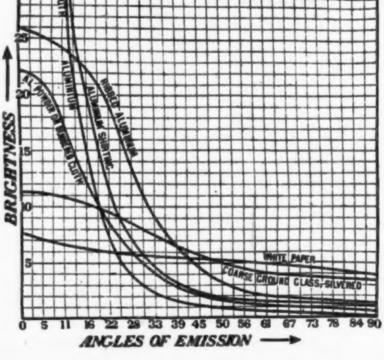
Screen.	30% diffusion efficiency.	Reflecting power.	Total efficiency.
	%	%	%
Magnesium carbonate block	25	87	22
Aluminium paint, mirroroid B ..	55	25	14
Becker compound ..	54	63	34
Ground mirror	69	92	64
Ideal screen ..	90—100	92	—

The ideal screen, assumed by Nutting, is a mirror, the front face of which is composed of minute hexagonal facets, each being a concave mirror of sufficient diameter to reflect light at 15° to the axis. Dr. Nutting also obtained favourable results with a glass mirror silvered on the back and then ground on the exterior surface. Mr. Gamble has accordingly experimented with a screen of this type, mirrored at the back and sand-blasted on the front, which gave a marked increase in brightness in comparison with the ordinary matt white surface. Screens about 6½ ft. by 4½ ft. of glass, ¼ in. thick, which would be suitable for use in small rooms were made, and gave the same brightness as that of the best white screens with one-half to two-thirds the current consumption. The glass screen also appears to give an indescribable effect of "life" not otherwise attainable. It has been suggested that with a film exhibiting great contrasts the brightness of the high lights might be excessive. The author proposes to meet this objection by using a neutral tinted screen of small absorption in front of the projector-lens. This can be inserted when necessary, diminishing the brightness of the picture as a whole without affecting the degree of contrast. Screens should always have a border of appreciable width and low luminosity.

* *Trans. Illum. Eng. Soc.*, U.S.A., Vol. xi., 1916, p. 92.

INDEX, June, 1920.

In the discussion, the President (Mr. F. J. Cheshire) referred to a paper by H. Lehman on screens, read before the German Physical Society in 1908. The diagram shows the relation between the brightness of image and the angle of obliquity at which the screen is viewed, based on experiments due to this author.



A NEW MERCURY VAPOUR LAMP FOR ALTERNATING CURRENT.

In *Comptes Rendus*, M. H. Georges describes a new form of high voltage alternating current mercury vapour lamp. In ordinary circumstances it is only possible to run such lamps on an alternating supply by the use of special electrodes. M. Georges, however, overcomes the difficulty by introducing neon gas into the tube, which is of quartz. The lamp is connected to a 110/3,000 volts transformer and when first switched on exhibits the characteristic spectrum of luminescent neon. This, however, is quickly replaced by the mercury spectrum, as the mercury volatilises, and in seven minutes the lamp attains a steady state. There is then a drop of 50 volts per cm. of tube, and an internal temperature of 700° C. is attained. The present lamp consumes 1 ampere at 2,250 volts, but it is hoped to construct lamps taking up to 10 kw. and furnishing the most powerful source of ultra-violet energy known.

TOPICAL AND INDUSTRIAL SECTION.

[The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

PROGRESS IN GAS-FILLED LAMPS.

We have received from several of the leading makers of electric gas-filled lamps intimations of the introduction of 40-watt 100–130 volt and 60–watt 200-260 volt lamps of this type. Such lamps, needless to say, should have important applications in many cases where the high consumption of so-called "half-watt" lamps has hitherto prevented their introduction.

Two "Mazda" types of such lamps, as furnished by the British Thomson-Houston Co., Ltd., are illustrated. Both lamps have ring filaments and can be operated in any position.

Fig. 1.—Mazda Gas-filled Lamp, 40–watt, 100-130 volts. (Approximate overall dimensions, 4¾ in. by 2⅜ in.)

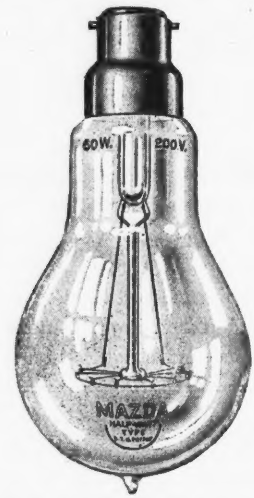


Fig. 2.—Mazda Gas-filled Lamp, 60–watt, 200-260 volts. (Approximate overall dimensions, 5¾ in. by 2¾ in.)

Messrs. FALK STADELMANN & Co., Ltd.

New Catalogue of Fixtures.

We have before us the new edition of the Electric Fixtures catalogue of Messrs. Falk Stadelmann & Co., Ltd., which is a comprehensive production, many different types of chandeliers, pendants, statuettes, and shades and glassware being illustrated. Full particulars of codes for ordering goods by telegraph are given at the end of the catalogue. We notice that the present list does not include semi-indirect lighting, but we understand that this will be dealt with in a special supplementary catalogue to be issued before the autumn of the present year.

"H. & H." HART-SNAP SWITCHES.

A recently-issued catalogue of the General Electric Co., Ltd., deals with the "H. & H." Hart-Snap switches, a form of rotary switch which is stated to possess advantages in many cases where the ordinary tumbler variety cannot readily be applied. The makers of the switch, for which, we are informed, the G.E.C. have assumed the sole selling agency in this country, are the Hart & Hegeman Manufacturing Co., of Hartford, Conn., U.S.A. The mechanism is simple, and special varieties of switches are available for heaters, electroliers, etc., the latter obviating the necessity of having several switches in one room in order to obtain the desired control of groups of lights.

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The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

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EDITORIAL.

Statistics on Industrial Lighting.

A few months ago reference was made to an instructive survey of Industrial Lighting in fifteen of the United States by Mr. R. O. Eastman, in which an attempt was made to ascertain the views of managers on the benefits to be derived from improved illumination. The assembly of opinions on this point is one useful weapon for the illuminating engineer, but an even more powerful one is the collection of actual data illustrating the relation between good illumination and freedom from accidents and efficiency of work.

The desirability of data showing the influence of lighting on output was emphasised by Mr. Ward Harrison in a recent address before the Taylor Society, a body in the United States which makes a scientific study of industrial production, and which is therefore in a favourable position to conduct tests on this point. It is pointed out, however, that such tests have to be conducted with considerable care in order to yield comparable results on a uniform basis.

There are many other factors besides lighting which have an influence on production, and these must be carefully eliminated. Changes in

personnel, variations in the quality of materials supplied, weather conditions, the past history of the workers, and particularly the proximity of holidays—all these have their effect on the work of the factory. Another point insisted upon is that the workers should, if possible, be kept in ignorance of the fact that they are being experimented upon. The knowledge that a test is being conducted is apt to arouse suspicion in some minds, whilst in others it may induce special effort or nervousness which may easily alter the ordinary routine of work. Changes in the lighting should also be made as unobtrusively as possible, especially if a return, for the purpose of a check, is made to the old standard of illumination, which prevailed before improvements are introduced.

It will readily be understood, therefore, that some difficulties may be expected in making a prolonged test of this character, even if the consent of the management is obtained, and much patience may be necessary. The same applies to information regarding the causation of accidents. There is, perhaps, less hostility to be feared from workers, seeing that the tests are so obviously made for their benefit, but the disturbing factors are possibly greater, and it is necessary to cover a very wide ground in order to obtain reliable results.

These considerations emphasise the need of securing the goodwill of the workers in making such inquiries, in order to pave the way for systematic surveys. If their interest could be excited, much useful information could be obtained regarding facts met with in their experience, even before a comprehensive study is undertaken; indeed, the accumulation of facts in this way is a necessary preliminary to the full inquiry, as it would indicate the most profitable lines of investigation and reveal pitfalls to be avoided. Foreman engineers in particular should be able to furnish from their experience many instances of accidents traceable to inadequate illumination. The industrial councils now being formed in a number of industries under the Whitley Scheme furnish a useful channel of inquiry, in view of the fact that both management and employees are represented, and that inquiries into the results of unsatisfactory illumination are obviously for their common benefit.

It is interesting to observe that Mr. Harrison confirms the general impression that work on night-shifts is usually less efficient than on day-shifts, the production in the former case being 10–25 per cent. lower than in the latter. This is in accord with the available information on accidents, which have been shown to be more prevalent by night than by day. The question arises, therefore, how far these better results by daylight are due to the arrangement of the lighting, and how far to the much greater intensity prevailing. Artificial light being under much better control than daylight, there should be no difficulty, in the average factory, in securing comparable conditions as regards diffusion of light. As regards amount of light, due regard must be paid to the remarkable power of the eye to adapt itself to varying intensities of illumination, provided the changes are not too sudden, and glare and excessive contrasts are avoided. There is some evidence, however, to show that in many industrial processes the limit, beyond which an increase in illumination produces no corresponding gain in efficiency, is much higher than is generally believed. This is one problem that does not admit of speedy solution, and is best solved by consultation between lighting experts and representatives of the industries concerned, and by the examination of results obtained during a long series of tests.

The Use of Architectural Features as an Aid to Lighting.

The discussion on the lighting of churches before the Illuminating Engineering Society a few months ago revealed a disposition to recommend the avoidance of very large chandeliers, such as were common in the past, in favour of more or less concealed methods of lighting, involving the placing of lamps amongst the architectural features of the interior. The idea is to use some actual feature of the walls or ceiling, *e.g.*, niches in the walls or domes, or slots in the ceiling, as a contrivance which takes the place of the lighting fixture in its ordinary sense.

It need scarcely be said that the method is not of general application, but there are many interiors to which it might quite appropriately be applied. Theatres, cinemas, concert halls and places of entertainment are cases in point. Such buildings are mainly used at night time, and their interiors ought accordingly to be specially designed with a view to the best use of artificial light. Light-coloured surfaces such as readily reflect and diffuse the light are necessary to the success of such methods, which naturally involve the co-operation of the illuminating engineer and the architect at an early stage in the design of the interior. The wiring is not invariably simple, and the designer can greatly facilitate the work of wiring by providing means by which wires can be easily inserted and readily replaced if defective.

We can recall several cinemas and theatres in this country where these methods have already been used with good effect. Readers will recall the recent account in our journal of a subway in the United States where the lighting was carried out by means of diffusing panels let into the walls, while on the underground railways of London a very similar idea has been utilised, only in this case the lamps are mounted in recesses in the ceiling. In the present issue we refer to an interesting street-lighting installation, described by Messrs. A. C. B. Halvorsen and A. B. Odey before the Illuminating Engineering Society in the United States, in which lamp-posts were dispensed with and the illumination provided by panels let into the parapets. The method would naturally only have a limited application for street lighting, but on bridges, and on terraces and the façades of buildings, there are many opportunities for the exercise of ingenuity in this way.

At present when lamps are installed outside buildings, it seems to be invariably assumed that the lamp must be either hung from a bracket or mounted on an upright springing from a pedestal. This is probably a survival of the days when only flame-sources were available. With modern illuminants there is much greater freedom in the location of the light source, and the art of making this an integral feature of the architecture seems to be only in its infancy. In assisting us to devise methods of lighting independent from the bracket, the suspended source and the pedestal fitting, the architect might do considerable service to illuminating engineering, and we believe that there is here a most favourable opportunity for the exercise of his craftsmanship and artistic perception.

The History of Church Lighting.

The short history of Church Lighting, which Mr. J. Darch contributes to our present number (pp. 201–209), forms a useful supplement to his paper read before the Illuminating Engineering Society in April last.* An interesting account is given of the methods of lighting, adopted by the early Christian churches. As illuminants these were extremely primitive, consisting at first of dishes containing oil or grease, and later of candles. Presently candles came to form an actual part of the religious service, and wealthy donors frequently contributed costly and elaborate candlesticks and candelabra.

It is curious to note, however, that the use of candles in ceremonial was apparently a source of much controversy in the early churches. Such discussions doubtless go far to explain differences in tradition in church lighting. However this may be, there can be no doubt that on the whole the use of light has been intimately associated with worship. Dr. M. Gaster, in a series of articles that appeared shortly after the starting of this Journal,* has shown how veneration of light, primarily the light of the sun and the heavenly bodies, formed the basis of many of the ancient religions; and how even when light was not actually an object of worship, it nevertheless came to form an essential element in religious service and celebrations. The study of these religious associations of light has much of interest to the illuminating engineer.

The introduction of modern illuminants only came about at quite a recent date. Some instances are quoted in the article on cathedrals, which only sanctioned the use of gas and electricity after it had long become familiar in other types of buildings. In a few cases, on the other hand, enterprising but premature attempts seem to have been made to use new illuminants almost immediately after their introduction, and before they had really reached a practical stage. Experience of modern systems of lighting in churches is very short in comparison with the long period covered by ecclesiastical history. One can readily understand that there may often be a disposition in favour of retaining candle-fittings (possibly valued gifts dating from bygone years), even though these large metal chandeliers, originally designed to carry a large number of candles or small oil lamps, would not now be necessary or even desirable with modern high candle-power lamps. It is also, perhaps, not unnatural that the use of gas and electricity should be suspected by some as incongruous in these old buildings, and patience is needed to dispel this impression.

It is the task of the illuminating engineer to show how the requirements of the service can be met by adequate lighting, and yet in a manner in keeping with the traditions of the church illuminated. In this work he must be prepared to co-operate with the authorities associated with the church and to take their views into consideration, and it is also much to be desired that lighting conditions in churches should be studied by the architect, on whose advice action is frequently taken.

LEON GASTER.

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* Vol. II., 1909, pp. 371, 462, 520, 586, 660, 731, 804.

A SHORT HISTORY OF CHURCH LIGHTING.

By JOHN DARCH.

A NUMBER of historical and other references met with in the preparation of the paper recently read by the Author before the Illuminating Engineering Society,* was precluded for want of space and it was thought that, arranged chronologically, they would form a useful appendix. My wish, however, is to refer, mainly, to those facts which bear upon the principles enunciated in that paper. The story of the development of art in lamp and candelabra, though interesting, must be looked for elsewhere.

I. IN SECRET CHURCHES, A.D. 33 TO 313.

The earliest record of an evening Christian Church Service seems to be that in Troas, about A.D. 59, mentioned in Acts xx. 7, 8, when in the "upper room" (usually reserved for worship or conference) there were "many lights." (Lamps.) There are frequent references to "candles" in the authorised version of the New Testament but they should, in all cases, read "lamps," while the "lamps" of the ten virgins should read "torches," *i.e.*, flaming fibre in oil cups on a stick. Oil lamps were almost exclusively used in Palestine, for olive oil was abundant and candles rare.

The Roman persecutions of the Christians, from A.D. 64 onwards, were, certainly, only local and spasmodic, but the ever present fear obliged the Christians to establish secret churches—largely in the more retired portions of the houses of the wealthier members,† so that artificial lighting was essential. Ceremonial lights were not used and there were no altars.

The Lamps that have been found bearing Christian symbols do not belong to this period. Those of terra-cotta were just the cheap commercial articles in common use, of which Fig. 1 is a typical

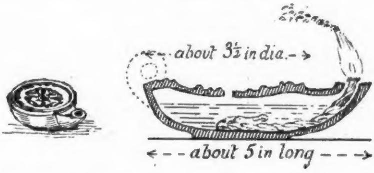


Fig. 1.—Section of Terra-cotta Lamp with or without handle.

section. The nozzle had to be kept low to ensure a free flow of oil and, even then, the wick which was of loosely twisted flax or rush, needed frequent trimming with tweezers or a hook. There is a hole in the top for filling, but made small to prevent splashing. The flame was smoky and the efficiency low; glare did not trouble them as much as soot and smell. Some lamps had two or more nozzles to give more light for the reader. I have dwelt on the details of this as it was the lamp of the ages.

Bronze lamps (and probably sheet copper or a copper alloy, brass being unknown) would be used in the oratories of the better houses They generally have a base and a cover, like a tea-pot, with a large significant handle; sometimes there was a chain or hook for suspension. Some of the lamps that have come down to us are works of art, but their lighting efficiency was no better than that of the earthenware lamps.

The Candelabra would, generally, be simple wood stands of a light portable character (the shaft was frequently

* ILLUM. ENG., May 1920, pp. 141-157.

† One church in Rome met at the house of Prisca and Aquila (Rom. xvi. 3, 5). There was also in the house of Rufus Pudens, a governor who married a British princess, a vaulted room, which still exists under the Church of S. Pudenziana, now known as the oratory of St. Peter, and which I have had the pleasure of examining.

of bamboo) or they may be more gracefully designed. (Fig. 2.) Here and there one might have met with the more patrician bronze or marble candelabra. The lamps were sometimes placed on brackets or in wall niches, as may be seen in the catacombs.

Fig. 2.—Pillar and Hanging Candelabra.

The suspended candelabra were small plaques or larger rotæ (wheels) as in Fig. 2 of wood, sheet copper or bronze, on which the lamps were usually placed promiscuously.

II. IN THE CHURCH CATHOLIC, 4TH TO 18TH CENTURIES.

It is one of the wonders of the human race that it has suffered the smoky primitive lamp and the snuffy guttering candle all through this long period, to say nothing of the many centuries before, without achieving the slightest improvement in their efficiency or in the principles of lighting, until the 19th century.

Practical necessity was the sole object of lighting in the early free church; but, in the Middle Ages, lighting, to enable the worshippers to join in the responses or canticles in dark mornings or evenings was a thing unknown. Reading and singing were the business of the clergy and choir, while the people knelt outside the rood screen in a darkness "made visible" by a few twinkling candles or lamps disposed here and there.

The natural result of the Constantine edict of religious freedom, A.D. 313, was a rebuilding of destroyed churches on a larger scale. Optatus states that at the end of the 4th century there were as many as 40 large Christian churches in Rome. Constantine gave them no less than 174 candelabra, representing nearly 9,000 lamps; one candelabrum was said to be of gold, with 500 dolphins, each holding a lamp. Paulinus (A.D. 420) describes the altar as crowned with crowded lights —*i.e.*, hanging over the altar.

Oil lamps, though never entirely displaced, gave way in time to a preponderance of candles. Both beeswax and tallow were used, but wax gave a cleaner light and burnt slower than tallow. Ure found an intensity of illumination of 14 to 10 in favour of wax per unit of consumption.

The Ceremonial use of candles was the subject of fierce controversy in the Free Church from the 2nd century onward, but did not come into general usage until the 4th century. It was enforced by Pope Gregory in A.D. 590 and confirmed by the Nicean Council in 787, also for votive purposes. Altar lights were not, however, in use until the 12th century.

The Paschal candle was always of beeswax, but later all liturgical candles had to be of the same material, and were sometimes made with broader bases for greater security on the prickets, or, in the case of large candles, for standing alone.

Lamps.—There are few Christian antiquities in greater abundance than the cheap earthenware lamps, but none date

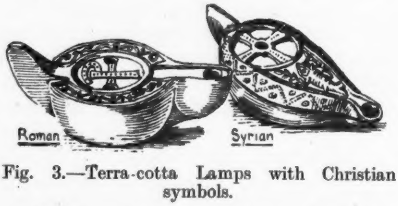


Fig. 3.—Terra-cotta Lamps with Christian symbols.

earlier than the 4th century or later than the 7th. They are similar to those already described, excepting that they bear such Christian symbols as the cross, the fish,

the palm, and the Constantine monogram ☧ The catacombs have yielded hundreds of the circular type, and excavations in Syria and Egypt of the butter-boat type, as Fig. 3. Many bronze lamps with well-executed Christian emblems have also been preserved.

Candelabra.—I can only refer to the principal types used in churches.

Pillar lampstands, as used before the Christian era, were adopted in the Church from the first, and have persisted throughout, for even the 20th century has seen such additions to St. Paul's Cathedral. During the earlier centuries we find both the slender (Fig. 2) and massive types, in wood, bronze, and marble, and all breathing the elegance of Greek art.

The seven-branched candlestick after the Mosaic pattern (Exod. xxv. 31) inspired many a priest of the Romanesque period. The most characteristic copy is that at Essen of A.D. 1003 ; it is 6 ft. 6 in. wide (Fig. 4), and of which a beautiful bronze facsimile may be seen in the South Kensington Museum. Other churches possess examples larger and more costly. They stood before the altar.

Fig. 4.—Seven-branched Candelabra at Essen.

The triangular candelabrum (for candles) (as Fig. 5) was a 15th century development of the latter.

The Classic Renaissance of the 16th century produced some notable work. Fig. 6 is one of the bronze candelabra standing on the altar rail of the Certosa, Paira, and Fig. 7 is one of four copper pillars that stood in Whitehall Chapel

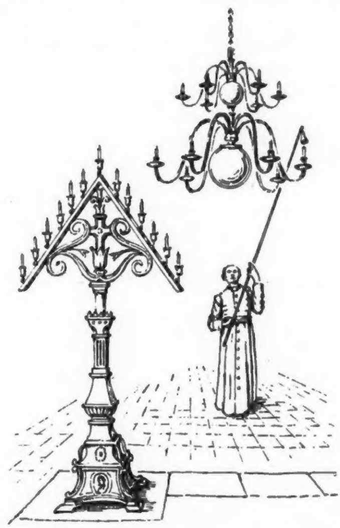


Fig. 5.—Triangular Candelabra and suspended "Spiders."

Fig. 6.—Bronze Candelabrum at the Certosa, Paira. Height 6 ft.

Fig. 7.—Copper Candelabrum from Whitehall, now in St. Bavon, Ghent. Height 10 ft.

till about 1655, when they were sold by Cromwell's Commonwealth and are now in S. Bavon, Ghent; they are 10 ft. high with marble bases, and still bear the English arms.

The Chandelier (as we use the term) has already been referred to in its simple form. It developed during the 5th to 11th centuries in the rota or wheel form, but with fixed places or prickets for lamps or candles. As wealthy donors were moved to do the thing handsomely, they increased in size and magnificence. Pope Adrian, in the 8th century, gave one furnished with 1,370 candles. In the Romanesque period the great Hildesheim chandelier was given (A.D. 1050); it is 20 ft. in diameter, and has 72 candle holders (Fig. 8); a full-sized model hangs in South Kensington Museum. This and others, similarly cumbersome, at Aix-la-Chapelle, Treves, Rheims, etc., make amends only in their more equable distribution of light.

Fig. 8.—Hildesheim Cathedral with the great Corona.

In the Gothic period (14th century) the corona became smaller with grease cups and prickets or sockets for candles, and some were made in triple tiers—"crowns of glory," that served the good priest for many a homily. Another type of Gothic origin had a central body sometimes in lantern or castellated form with statuettes and arms with sockets for candles.

Altar Candlesticks came into use in the 12th century. At first in the squat Romanesque form, of bronze, and later they developed into the more elegant and costly Gothic of brass or silver, and jewelled.

III. IN GREAT BRITAIN TO THE 18TH CENTURY.

The Church of England during the Roman occupation, from its first church at Glastonbury, founded A.D. 60, to that of the Martyr St. Albans in the 4th century, used the ancient Roman lamp and candelabra already described.

From 1070 to 1536 the church was ruled from Rome and had the same liturgy and pretty much the same lighting customs. Night services in parish churches were exceptional, but for early matins or late evensong, principally in the abbeys, cressets or candle lanterns were all that were considered necessary beyond the liturgical candles.

Lamp niches* are an interesting feature and illustrate my contention (p. 145) that the mediæval architects had no compunction in adapting structural features to lighting requirements. At Patrington Church we have a forecast of concealed lighting. It is a square stone boss, as Fig. 9, containing a plain chamber for a lamp to shed a mysterious light from nowhere on the altar. At Lichfield is a lamp niche $8\frac{1}{2}$ in. by 10 in., with a flue to the outside.

Fig. 9.—Lamp Niche at Patrington.

Candles of tallow or mutton fat had to serve for ordinary church lighting, as olive oil was scarce and little used, although wax candles were sometimes employed. A 15th century church inventory mentions, " Item. iiij candylstykes of laton† with braunches for Talough candell." In the accounts of St. Margaret's Church, Westminster, for 1505, we read, " For candyll for burning in the lanteryn on wynter mornings in the body of the churche Xd," also " for a dossen of Candyll to set aboute the churche uppon Christenmasday in the mornyng XIId." (probably wax). In 1704 St. Paul's Cathedral spent £1 in tallow candles but £18 in wax.

Cresset stones were used for lighting the church and its precincts. They were pots or hollows worked in blocks of stone, to be filled with oil or grease with a floating wick. An old French author refers to one as a " crasset lampe de nuit." The stone cresset was a fixture, whereas the better known cresset was a grease pot or cage of inflammable material fastened to a pole and used in procession, or fixed in the earth as a beacon, or to light the approach to a church. In the *Rites of Durham* we read :—

> There is standinge on the South pillar of the Quire doore of the Lanthorne, a foure square Stonn, which hath been finely wrought . . . with twelve cressets, which was filled with tallow, and every night one of them was lighted when the day was gone, and did burne to give light to the monkes at midnight when they came to mattens.

At Lewanwick Church, Cornwall, there is a polished granite cresset, as Fig. 10, 18 in. top diameter and 7 in. thick, with seven holes $2\frac{1}{2}$ in. diameter and $3\frac{1}{2}$ in. deep, and standing on a base 14 in. thick.

At St. Mary's, York, the well-known ruined abbey which Mr. Crompton illumined in the early days of arc lamps, there is a limestone cresset, as Fig. 12, 13 in. by 8 in. by 5 in. thick with six holes. We have a corbel cresset in the Norman Church of Dereham, Cumberland, top projecting face 10 in. by 10 in. and $8\frac{1}{2}$ in. deep, as Fig. 11, with one cresset hole. Further examples are extant.

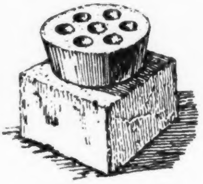


Fig. 10.—Granite Cresset, Lewanwick Church.

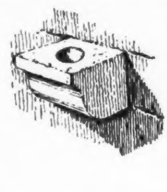


Fig. 11.—Cresset Corbel, Dereham Church.

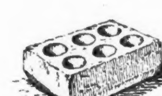


Fig. 12.—Cresset Stone, at St. Mary's, York.

Chandeliers, when they took the corona or wheel form, were known as " rowells," and when hung before the rood or in the chancel, might carry from 10 to 20 candles. They were lowered by pulleys. A will in 1494 bequeaths wax for " xij lyghtes breuning afore y^{e} roode, in y^{e} rowelle."

* Antiquarian Journal, Vol. XXXIX, 1882.

† Latten, sheet brass or other alloy.

Later, the Gothic form of chandelier had a central stem or body with statuettes or grotesques and foliated branches. Towards the 18th century Dutch influence brought in the "spider" form, *i.e.*, globe bodies with long slender swan-neck arms in one, two or three tiers (Fig. 5). These may be seen in many churches; two fine specimens are at the South Kensington Museum and a large one at Holy Trinity Church close by.

Candlesticks.—Not many Paschal or altar candlesticks survived the iconoclasm of the Reformation. The good folks of Durham "estimated" their "Pascall to be one of the rarest monuments in all England," and a description is given in the *Rites of Durham.* By an act of chapter in 1579, however, it was decreed "that the Paschal shall be defaced by the officers." They tell me that no Paschal has been substituted since.

The pair of floor candlesticks before the high altar at Westminster Abbey represent a Gothic type and is of 15th century of gilt hammered brass with cast dogs, etc., at the base A length of stem has recently been inserted, see Fig. 13.

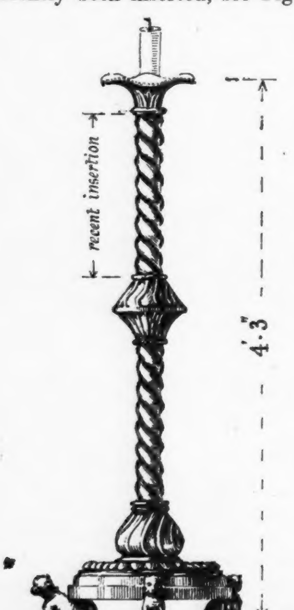
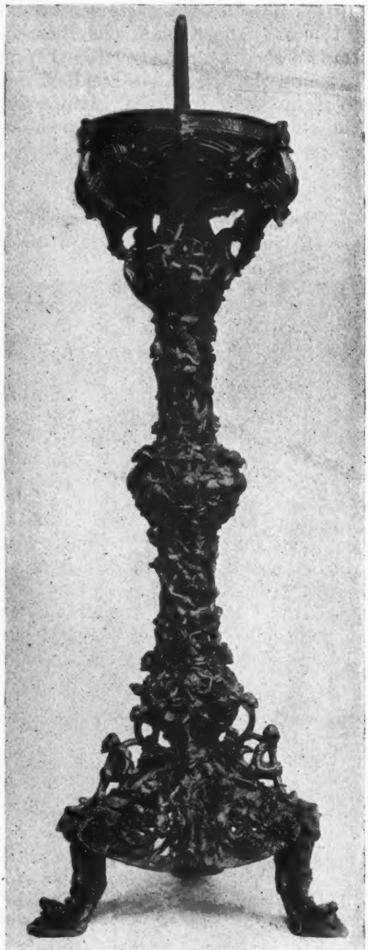


Fig. 13.—Gilt brass 15th century Candlesticks at Westminster Abbey.

Altar Candlesticks, which came into use in 12th century, were frequently given to the Church. The earliest extant and most remarkable is the Gloucester Candlestick, an elaborately cut and pierced mass



By permission of the Victoria and Albert Museum.

Fig. 14.—The Gloucester Candlestick of gilt bell metal. Height 23 in.

of grotesque figures and foliage with a spiral inscription to the effect that it was given by Peter the Abbot to the Abbey of Gloucester about 1100. It is English work and now stands in a case in the South Kensington Museum, see Fig. 14.

In poorer churches the altar candlesticks were of thin sheet metal or pewter. Later they were mostly of cast brass about 18 in. high. Fig. 15 is a characteristic example of 17th century, English, from Armagh Cathedral and now in South Kensington Museum. Stow, in 1590, refers to a candlestick factory in Lothbury, London. Many of the cathedrals have beautiful silver examples from 15 in. to 26 in. high, but all are of 17th century or later. The pair of candlesticks on the high altar of Westminster Abbey were given by a domestic servant in 1691, and are of gilt silver, 30 in. high, chased and in high relief, and valued at £1,000.

Fig. 15.—Cast brass Altar Candlestick, 18 in. high. Armagh Cathedral.

Ceremonial Lights.—The Sanctuary lamp was introduced in the 13th century and continued until the Reformation. In a will of 1472 it was provided that the churchwardens of St. Mary-at-Hill, London "shall fynde and susteyn for evermore a lampe with oyle in the quire to burn alwey as well on Days as on nyhtes."

"On candlemas Daye the bearynge of candels is done" (A.D. 1520). And the bigger the blaze the greater the satisfaction. But the most important candle function was the Easter blessing of the great Paschal Candle which stood before the altar, one at Westminster Abbey in 1557, requiring 300 lbs. of wax. At that and other festivals the rood beam was decorated with candles, or what we should call a "batten" was furnished with pewter or brass cups or spikes (long nails driven through) for candles.

Pure beeswax was usually bought from the local farmers by the sacristan (contr. Sexton), and the candles either made by him or by an itinerant chandler. Many curious entries of wax purchasing are to be found in warden's accounts. Also such items, in 1517, as "For Snoffers of plate for to put owte the tapours Vd."

Since the abolition of papal authority in 1534 the use of lights in ritual has not been consistent. In the Puritan period (1560–1660) "candle religion," as it was called, was abandoned in all Protestant Churches and was not generally restored in the Established Churches until after the development of the Oxford Movement in 1860, since which altar lights have become general, though optional. The Mackonochie case in 1872 and the Lincoln judgment in 1889 have still left the ecclesiastical law of lights undecided.

IV. THE NEW LIGHTING ERA.—19TH CENTURY.

The last few years of the 18th century gave birth to a new genius of lighting which irradiated the entry of the greatest century that the world has known. Almost at one stroke the ages old primitive oil lamp and candle were transformed and unimaginable new lights created and again reformed.

Education had a profound effect on church life. No longer was the Church of England able to hold the consciences of the people; the rood screen was removed and the surplice ceased to command its privileges, for the congregation became capable of taking an equal part. These facts intimately touched the lighting question and are at the root of the arguments of the foregoing paper.* The people needed to read easily, to clearly see the preacher, the sanctuary and the church; while lights must not interpose as of old. Naturally, these remarks apply only to the great majority of our churches and chapels; there is no intention to assail the faith of those who cling to the observances of the 13th century or those, such as the spiritualists, who sincerely employ darkness and mystery in their propaganda.

* See ILLUM. ENG., May 1920, p. 142.

The New Oil Lamp.—When Argand brought out his 10 candlepower lamp in 1782, with its perfect combustion of colza oil, it created a sensation, for no one had ever seen a lamp with a bright, immovable and smokeless flame and with which it was possible for those who could read to do so in church.

But the viscidity of all oils had ever been a drawback to the use of lamps, and when, in 1850, Mr. James Young produced his paraffin, a limpid mineral oil that rose freely up the cotton wick, it led to a great number of country churches using oil lamps, after ten centuries of candle lighting. Cheap petroleum (kerosene), which came on the market a few years later, gave lamp making for churches a great impetus. The best single and duplex burners gave 20 to 30 candlepower and the annular burner 40 to 50 candlepower. Within the last 15 years we have had the oil-fed incandescent mantle with its 50 candlepower. Oil lamps were (and are still) in use in hundreds of churches, but they were usually hung low and obstruction and glare began to operate.

The Reform of the Candle.—In 1810 the snuffless wicks were introduced and, though slowly adopted, none felt their benefit more than the church. The introduction of stearine (1830), paraffin wax (1870) and vegetable wax and their mixtures gave us a candle that, for church use, equals the cleaner and intenser light of beeswax at much less cost. Nevertheless, for liturgical purposes, the Catholic and Anglican churches decree beeswax, but the order has been relaxed to a minimum of 65 per cent. Candles are an expensive mode of lighting, but 100 candles, properly distributed, give a better general illumination than two 50 candlepower lamps equally exposed.

Coal Gas.—Samuel Clegg, the gas pioneer, laid down one of the earliest experimental plants for lighting up Stonyhurst Catholic College in 1810. If the Chapel, now rebuilt, was included it would be the earliest sanctuary to be lit with gas. The first public supply was the Gas Light and Coke Co., chartered in 1812, but others quickly followed all over the country.

The first ordinary church to be lighted by gas would appear from Accum's book to be St. John the Evangelist, Smith's Square, London, in 1813. But the churches generally seemed to be shy in adopting gas lighting. Some thought that " it would make a church look like a gin palace," but the Pope's objection was more explanatory. The *Journal of Gas Lighting* of 1848 reports that when the Pope was waited on for his consent to a new Roman Gas Co. he refused it, disclaiming the new light as " utterly subversive of religion," and that " candles would be rendered ridiculous beside the glaring gas and a custom essential to everlasting salvation would fall into disuse."

It was not until about 1860 when Mr. Bray began to improve the burners that the churches took more freely to gas lighting. Durham Cathedral kept on with candles till 1870. St. Paul's Cathedral had no evening services until 1858, and on dark days candles sufficed, but in 1852, at the Duke of Wellington's funeral, gas was installed in " illuminations " form round the arches and round the dome; it was little used after, although the fittings remained until 1900.

The first rational principle of illuminating churches came with the invention of the ventilating sunburner, by Mr. Alfred King, in 1866, and improved upon soon after by Mr. Strode, who fitted up the Brompton Oratory and a number of prominent churches and chapels in London with them. A witness of one of the earliest of these said: " It is difficult to describe the beauty and agreeable glow of this method of illumination without having witnessed it."* That was 50 years ago.

From 1890 the Welsbach incandescent mantle, which gave 40 candlepower where 12 or 15 had been before, was readily taken up by the churches and made their interiors much more cheerful, but the glare much more painful.

The sunburners above mentioned, although remaining in many churches, are largely out of use, due to the lower illuminating quality of gas supplied since the introduction of mantles. This difficulty was met by a Scotch firm about

* See " Overhead Lighting," p. 149, ILLUM. ENG., May, 1920.

1908, who introduced a ventilating sunburner of high power with clusters of small mantles, and these have been fitted in many churches in the north, with good results.

Electric Lighting was taken up by the more enterprising churches shortly after the introduction, about 1881, of the carbon filament lamp, and gas and candle fixtures were invariably employed.

The earliest record that I have is of Dr. Parker's City Temple, London; it was of a break-down at the watch-night service of 1882. A number of well-known churches installed electric lighting during the next three or four years, including St. George's, Hanover Square, and the ancient Temple Church, but the greatest business in churches was between 1890 and 1895; after this the influence of the new gas mantle was felt. The first church to be lit with electricity in the north of England was Hetherington, Durham, in 1886, and the first in Glasgow, Hillhead Baptist, also in 1886.

Electric lighting was installed at St. Paul's Cathedral during 1900-2, by the munificence of Mr. Pierpont Morgan, at a cost exceeding £10,000. Experiments were previously made with concealed lighting, but abandoned as "theatrical." The beautiful chandeliers and other fittings look well by daylight, but how far the installation has been successful in lighting the building anyone who attends an ordinary Sunday evening service may judge.

Acetylene.—This highly illuminating gas first became commercially available in 1894, and so great was the rush of inventors of apparatus that lighting was in full swing in 1898, and I hear of a church that was lit by a Gravesend man in that year. From 1899 to 1909 acetylene was installed in hundreds of country churches. New fittings were generally necessary for this brilliant gas, but no advantage seems to have been taken to improve on the bad old methods of glare.

The Emerging of the Art of Illumination.—The establishment of rational principles in the art of illumination must be assigned to the 20th century. That light is a good servant but a bad master has been frequently demonstrated, but that knowledge is very slowly affecting our hidebound customs. I sincerely hope that the 20th century will see as great a reform in the handling of light as the 19th century has in its production.

Count Rumford, about 1790, pointed out that light should be screened from the eyes, and designed lamps to that end.

Whilst researches were being made in light, photometry and optics, about the middle of the 19th century, town churches were establishing regular evening services and yielding object lessons in glare that did not escape notice. Since delivering the foregoing paper, I met with Mr. Richards' *Gas Manual* for 1865, and was so surprised and pleased with one paragraph that I must quote it.

> The common method of illuminating churches and chapels is to suspend a number of lights from the front of the gallery and on pillars in the body of the edifice; hence the people have to sustain the full glare of a large number of flames or lights which puts the preacher in comparative obscurity and has a tendency to produce drowsiness, and that which might be considered want of merit in the preacher is due to the defective art of lighting.

Nothing that has been said in these days so completely epitomises my arguments in the foregoing paper as this that was written 55 years ago, and now seen by me for the first time.

America took the first concerted lead by establishing her Illuminating Engineering Society in 1905 with a brilliant membership. This Journal was launched by Mr. Leon Gaster in January, 1908, and our own Illuminating Engineering Society was inaugurated in 1909. The first two years of the Journal and the eleven years' work of the Society have done more than anything else to spread a knowledge of rational systems of lighting and will, it is hoped, make the 20th century more fruitful than the 19th.

SOME IMPRESSIONS OF PRAGUE AND CZECHO-SLOVAKIA.

In the last issue of this journal a brief reference was made to the recent visit of a party of delegates from the British International Association of Journalists to Czecho-Slovakia, and the writer would now like to supplement this by some notes on his personal impressions of the country, and especially of the romantic city of Prague, one of the most remarkable and interesting cities in Europe.

A good deal has recently been written about this country by the members of the party, who have visited it, and various aspects have been considered.

Probably there are as yet few people in this country who have any clear conception of the Czecho-Slovakian Republic, which, comprising Bohemia, Moravia, and Slovakia, occupies an area of about 55,000 square miles. Of the Republic, Bohemia is best known, with its many artistic industries and its associations with music and drama. The industries include cotton and woollen goods, boots and shoes, gloves, porcelain, glassware, timber, bent wood furniture, etc. Although, like other countries, Czecho-Slovakia has its industrial difficulties, lack of coal and raw material being the main difficulty, it is already making preparation to export on a considerable scale. But those who wish to do business must understand the country and must appreciate particularly the need for longer credit facilities which form an important feature in transactions in this part of Europe.

In our previous note we referred to the high artistic skill shown in many of the articles produced, notably the decorative lighting glassware for which Bohemia has long been famous, and the carved wood lighting fittings which form an interesting new departure.

The people are great lovers of music and the drama. When some years before the war, the magnificent theatre in Prague was burned down, the people would not rest until, by public subscription, they had raised the amount necessary for rebuilding. Recreation is carried on until a late hour at night, yet people resume work early in the morning. Prague, as the capital of Czecho-Slovakia, now enjoys much of the importance previously attached to Vienna. This change in status has led to a considerable increase in the population, which the traffic facilities are unable to meet satisfactorily. Many people have to walk to their work—the tramcars are over-burdened.

While the writer, who enjoyed the hospitality of the Czecho-Slovakian Government, is perhaps hardly in a position to judge the conditions of ordinary life in Czecho-Slovakia, it appeared that the people in general are moderately well fed; there was at least a great contrast in the appearances of the children as compared with those seen during the passage through Germany. The people seemed not only better nourished, but with a happier, more alert and more hopeful mental outlook. To visitors from England the rate of exchange naturally makes living relatively cheap, and Czecho-Slovakia and Prague well deserve a visit.

Prague, the City of a Hundred Spires, is situated amidst wooded hills and most romantic scenery. Many of its old buildings are of great historic interest. The Royal Palace, now the residence of the President, Professor Masaryk, and the various Government Departments, overlooks the rest of the town, and as the ancient residences of the Bohemian kings has many interesting associations. The vast Vladislav Hall is unique. Another venerable edifice is the City Hall, with its curious astronomical clock, whence issue at the striking of the hour, the figures of Christ and the Twelve Apostles.

An annual event for which preparations were in progress during our stay is the great Sokol Festival. The Sokol is an old-standing association, which is difficult to define, but plays an important part in

the national life. It combines the culture of the body with the teaching of patriotism in a wide sense, and has something in common with the Boy Scouts' Association in this country. It is, however, devoted to young people and grown ups alike. The vast Stadium where the festival was held this year can accommodate about 20,000 performers, doing their drill and exercises simultaneously, and the touch of colour in the costumes adopted by various groups and sections makes this combined display a wonderful sight. Another remarkable national asset is the great open air theatre at Sarka, which dates back for hundreds of years and is devoted to special plays, many of them illustrating curious legends or events in the national history. The stage is located in a narrow valley with mountainous sides, and the stage-foreground passes naturally to the adjacent scenery, groups of peasants descending from the hills in a most impressive way.

Finally, there are in Czecho-Slovakia some of the most delightful health resorts in the world. Carlsbad (now called Karlovyvaria) and Marienbad (now called Marianske Lazne), with baths, hills, and forests, are amongst the best known. The facilities for medical treatment are most elaborate and the medical gymnasia, baths, etc., are well worth a visit, even by those who are fortunately not in need of their assistance from the hygienic standpoint. During our visit everything possible was done by the Government to render the trip instructive and enjoyable, and there exists a genuine sympathy and respect for England, which will ensure visitors a pleasant reception. When it has become somewhat better known, Czecho-Slovakia may well claim to share with Switzerland the description —"the playground of Europe"; and I hope that it will form a centre of peaceful co-operation of the various nations engaged in restoring mutual confidence and assuring a brighter and happier future for the country.

I take this opportunity of expressing the thanks of the members of the party to the various officials who did everything they could to make our stay enjoyable and instructive, and in particular I should like to mention the names of Dr. Butter, of the Foreign Office, and Mr. Novctny, a most capable representative of the Czecho-Slovakian Press.

L. G.

STREET LIGHTING WITH LOW-MOUNTED UNITS.

STREET lighting has hitherto been carried out almost exclusively by means of lamps mounted on posts a considerable height above the ground. Occasionally, however, one meets cases where lamps at a relatively low level are useful. Such an instance is afforded by the roadway over the Kensico Dam, in the Brinx River Valley (New York), the lighting of which is described by Messrs. C. A. B. Halvorsen and A. B. Oday in a recent contribution to the Transactions of the American Illuminating Engineering Society.

This is approximately 2,200 ft. long and 26 ft. wide. There are stone parapets on either side and, at each end of the dam, pavilions surrounding a circular court. The architectural specifications for the dam precluded the use of posts, and it was accordingly decided to conceal lamps at the sides, flush with the parapets, and in the pavilions at each extremity of the dam. The parapet lights consisted of panels carrying a prismatic glass door let in flush with the surface, at a height of 26½ inches. Behind the door is a 6-volt 108-watt lamp, of the type used for automobile headlights, with a reflector behind.

Photographs of the installation by night suggest that the effect is quite pleasing, the lights being completely concealed from view, so that a person approaching one end of the dam sees only the illuminated roadway. The illumination along the centre of the roadway (approximately 0·06 foot-candles) appears sufficiently uniform. The method could presumably only be applied to fairly narrow streets or bridges, and where there is some form of parapet at the side where lighting panels can be concealed. But it seems to deserve attention in special cases of this kind.

THE NATIONAL PHYSICAL LABORATORY REPORT FOR THE YEAR 1919.

The report of the laboratory for the past year is a much more comprehensive one than in recent years, and indicates that work has now resumed its normal character, many investigations left in abeyance during the war being again attacked. Reference is made to the death of Lord Rayleigh and Sir John Brunner, both of whom have rendered conspicuous services to the N.P.L. It will be recalled that Sir Richard Glazebrook, the late Director, retired in September last, his place being taken by Professor J. E. Petavel.

As regards the work done during the past year, it is only possible to make a brief reference to a few matters of special interest to our readers. Apart from researches having an industrial bearing much information is given of various war investigations. During the war Mr. C. C. Paterson and Mr. J. W. T. Walsh were responsible for apparatus for finding the height of aeroplanes. (A kindred research mentioned is the exact location of sounds, under certain circumstances the surprising accuracy of ± 0·5 per cent. being attained.) Much work was also done by these two investigators on small gas-filled lamps used for aircraft-signalling, necessitating filaments arranged in two parallel spirals. About 50,000 dials with figures outlined in luminous paint have been tested by the arrangement already described in this journal; most dials are now well above the standard brightness of 0·0075 foot-candle specified in 1915, owing to the steady improvement in the quality of radium luminous compound. The experiments of Messrs. Paterson, Walsh and others on searchlight carbons have already been described in a paper before the Institution of Electrical Engineers. A fascinating problem that receives only casual mention is signalling by methods inappreciable to extraneous observers such as the use of infra-red or ultra-violet energy. Three such methods have been contrived, and one of them enabled signals to be transmitted from two to six miles in daylight. The absence of any sufficiently trustworthy means of measuring the intensity of ultra-violet and infra-red energy proved a difficulty in these researches.

Projection methods of testing screw-gauges have now become quite established. Some researches on travelling projectiles of small size were undertaken by means of shadowgraphs, *i.e.*, photographs of shadows caused by a small projectile passing in front of a vivid spark from a condenser; these experiments served to determine various points in connection with the stability and wind-streams of bullets. Tests of telescopes and gun-sights have naturally diminished in number during the last year. It is of interest to note that the deterioration in quality of optical glass, noticed in the early stages of the war, was not confined to this country, but was experienced in Germany as well. However, the best British products using such glass are now considered to be quite the equal of those produced abroad.

The section on photometry deals largely with problems arising through the extending use of gas-filled lamps. So far it has not been found possible to obtain gas-filled lamps giving as steady and consistent results as lamps of the vacuum type, but trials are being made with the object of obtaining a set of standards working near one candle per watt. The use of such lamps in small sizes for aircraft signalling has made it necessary to adopt some criterion of the temperature of the filament, based on the colour of light emitted.

It is recognised that gas-filled lamps should be rated in average (mean spherical) candlepower. Consistent results cannot be obtained by rotating the lamp, and the use of an integrating photometer is desirable to avoid the laborious work of getting measurements at different angles from a stationary lamp. The whitened cube set up in 1911 has proved satisfactory for ordinary work, but two spherical photometres, one of one metre and one of two metres diameter, are also to be prepared. The re-determination of the values of electric sub-standards, especially of the set operating at 0·68 candle per watt, was delayed during the war, but has now been recommenced.

THE RELATION BETWEEN ILLUMINATION AND OUTPUT.

In a paper recently read before the Taylor Society at Rochester, N.Y., Mr. Ward Harrison discussed some of the differences between natural and artificial light. The two chief respects in which daylight differs from artificial lighting are (1) lesser diffusion of light and (2) very much *less* illumination. Requirements as regards diffusion can be met to a great extent, but at present it hardly seems economically feasible to provide an intensity of artificial light equal to that of normal outdoor daylight.

Experience, however, goes to show that it is difficult to fix a limit to the amount of illumination desirable, provided the light is well diffused. Outdoor daylight illumination approaches 1,000 foot-candles; artificial illumination in industrial plants usually falls between ½ and 10 foot-candles. Good indoor daylight illumination is ordinarily considered to be not less than 15 foot-candles.

The question arises, "How far does it pay to go in increasing illumination?" Increased illumination enables us to see more, and especially when objects in motion have to be studied. Mr. Durgin's inquiries in Chicago* showed increases in production of 10—20 per cent. arising from better lighting, and this has been more or less confirmed by other less complete investigations. Further, night-shifts at present are notoriously less efficient than day-shifts, the difference in productive power being usually 10—25 per cent. It should also be remembered that in plants averaging, say, 100 square feet of floor space per employee the cost of good artificial lighting is usually not in excess of 0·1 per cent. of employees' remuneration during the period.

These considerations show the importance of tests of production by varied conditions of artificial light, and Mr. Harrison suggested to the Taylor Society, which is associated with the scientific study of industrial production, that this body should institute inquiries in the works with which members were connected. In the appendix to his paper the author, however, suggested various factors that needed to be kept in mind. Among these are:—

(1) The test should relate to a large number of workers supplied with uniform illumination.

(2) A separate work-sheet should be kept for each man.

(3) Such extraneous factors as humidity of atmosphere, time of year, days elapsing before and after holidays, etc., should be closely noted.

(4) A series of different values of illumination should be used in the test. It is best to start with the original illumination, increase the value, and return to the first conditions several times. A check should also be kept on production by daylight.

(5) Material supplied should be carefully studied, as this varies and may involve variations in output.

(6) If possible the fact that a test is being conducted should be kept from the knowledge of the workers.

(7) Close supervision of the men to ensure that they are all at work is necessary and changes in personnel should be noted.

(8) Any shut-down or discontinuity in work must be allowed for.

(9) Changes in lamps and reflectors should preferably be executed over the week end when workers are not present.

(10) Illumination should be measured at the beginning and end of hours of work, as well as at certain intermediate hours. Definite stations should be allocated for these readings.

* See Illum. Eng., October 1918, p. 229.

AN ABSOLUTE METHOD OF TESTING COEFFICIENTS OF DIFFUSE REFLECTION.

A new method of determining absolute coefficients of diffuse reflection is described by Mr. F. A. Benford in a recent issue of the *General Electric Review* (U.S.A.).* The method depends on the use of an integrating sphere, and has the advantage that no photometric standards are involved, and measurements may be made with uncalibrated lamps and unknown instrument constants, the only requirement being that the lamp and other accessories must remain constant during the test. In any sphere of this description the brightness of the interior depends upon (A) the quantity of light entering the sphere, (B) the coefficient of reflection of its inner surface, and (C) the solid angle of the spherical surface, if part of a sphere is used. In the method described advantage is taken of a variation of the third of these factors; by taking two readings with different areas the other two factors are eliminated, the comparative brightness in the two cases giving the key to the determination.

Accordingly the method consists in using a sphere with one or more removable sectors, of known solid angle, the inner surface of which is coated with the material to be tested. The brightness of this area may be compared with any convenient extraneous surface, such as the diffusing glass plate in a brightness photometer. A beam of light is directed into the sphere, but must not fall directly on to the surface coated with the material tested. The two coated sectors, of area A_1, A_2 are introduced in turn and their respective brightnesses R_1, R_2 observed. Then if S is the total internal area of the sphere, the coefficient of reflection, K, is given by—$S(R_1—R_2)/R_1A_1—R_2A_2)$.

With a view to accuracy it is desirable that—(1) A_1 should be large in comparison with S; (2) A_2 should be $\frac{1}{2}$ to $\frac{3}{4}$ of A_1; (3) all stray light should be quenched so as not to affect the part sphere, and (4) the method should be used with caution if K is less than 0·5. Generally speaking, the method is only suitable for materials having relatively high coefficients of reflection. In order to illustrate the method the author gives the results of some tests on silk-finished magnesium carbonate, the reflecting power of which is given throughout the spectrum. Apart from a slight diminution in the extreme red, this appears to be practically constant at the high value of 97·4 per cent. This extremely high figure comes as a surprise, but the author mentions that 88 per cent. has already been obtained previously with a reflectometer which is known to read low.

* January, 1920.

A ROTATING ARC FOR OPTICAL PROJECTION.

In the *Revue Générale de l'Électricité* an account is given of the Gabarini rotating arc, which is stated to have several advantages for projection work. The aim is to produce a very small but intensely bright source unobstructed by the negative carbon. The source of light is the crater of a cored positive carbon, arranged horizontally. The negative electrode takes the form of a metal ring, at the centre of which the crater is situated. This negative electrode is cooled by a stream of water or petrol. Being in the form of a ring it offers no obstruction to the light from the crater of the positive electrode, and is also non-luminous. In ordinary circumstances the arc would be very unstable and tend to wander in an irregular manner round the ring. To obviate this a solenoid is built round the positive, producing a strong magnet field, which causes the arc to rotate rapidly round the ring at 500—3000 revolutions per minute. The motion is so rapid as to be inappreciable to the eye, which only sees the central bright spot, the crater, surrounded by a faintly luminous haze. The negative electrode, being of metal and of large dimensions, remains cool, wasting very slowly. The only regulation desirable is to keep the positive carbon with the crater at the centre of the ring, and this is achieved automatically by the dilatation of the metal plate. It is claimed that the fact of there being no hot surfaces in the vicinity of the arc enables the latter to be brought much closer to the optical apparatus than is usually possible, and that mirrors or lenses of very short focus can be used.

CORRESPONDENCE.

LIGHTING CONDITIONS IN MINES.

Dear Sir,

With reference to the discussion on the above of February 24th, Mr. H. F. Joel asks for my opinion on the value of the principle adopted in the Fors-Joel lamp.

The glass being yellow, cuts off the violet rays, which in my opinion are irritating and of no value for vision in mines; therefore, as far as that goes, I think it is good, and a great step in the right direction. But, it also cuts off all the red rays, and this seems to me to be a disadvantage. Looking at the light of the lamp exhibited it appeared "cold" and not quite comfortable, owing, as I thought, to the lack of a little red.

Then I have not had an opportunity of seeing this light in a mine and observing what the coal, etc., looks like with it—and that is really the best place in which to judge a miner's lamp.

Judged on the surface, I should prefer a lamp of that sort to the present-day metal filament lamp with a clear glass.

My objection is to the *excess*, or relative *excess*, of blue and violet rays—not to a small proportion.

The eye has been evolved to use all light rays, and a variety seems to be beneficial. One gets tired of looking at one colour only, and that is what is likely to happen with using light filters, as an insufficient variety of rays can pass through them.

The miner's eyes get tired of looking at surroundings that are almost uniformly black; there is the monotony of colour, as well as the very small amount of light reflected.

Mr. A. P. Welch's proposal to put in lightly-coloured screens I think is quite feasible in places where one man, or two, may be working, with plenty of room, but they could hardly be used where a number of men work close together, as they would be too much in the way, and would be a source of danger from men tripping over them. What I think can be done is to pass all timber through a tank of light-coloured wash before it goes into the pit, and the roof could be whitewashed as it becomes exposed. But where oil lamps are used the benefit of white roofs is largely nullified by the shadow thrown on them by the lamps.

To bring the chromophotic index of a badly-lighted mine up to the safety margin of 500, I estimate that as a minimum a strip of surface six inches wide, and equivalent to 50 per cent. white is required to be within the field of vision of the miner: in other words, a light-coloured six-inch post, or board, and this without any increase of candle-power in the lamp, which may be as low as ·2. The light of the future will most likely be electric, although oil lamps give a light of very good quality on the surface, but not in bad air. With improved ventilation, and the addition of some light colour, I see no necessity for the immediate scrapping of oil lamps.

If metal filament or vapour lamp-makers can introduce some element into their lamps that will give off a light similar to the carbon filament, I think it will be decidedly better than using orange-yellow, or amber glass, but if this cannot be done, then such a glass will probably be the next best thing.

One has to remember that a collier may have to work with his lamp for 20 or 40 years, and therefore every endeavour should be made to produce a light that is absolutely comfortable to the eye. Dr. Llewellyn and others disagree with my suggestion that ultra-violet rays may cause incurable nystagmus. Since electric lamps were introduced into Ebbw Vale pits there has been a marked decrease in nystagmus, as was only to be expected, but I mentioned other factors

namely, more air, more daylight, shorter hours, and new men as well as lamps. Not enough time has yet elapsed to enable one to see whether the percentage of incurables will be increased. In my cases it was 5 per cent. My object is to take steps to prevent such an occurrence rather than to wait for it and then talk about how it should have been prevented.

As to bad air in mines, I am sure Dr. Haldane would not describe the air coming from some that I have visited as "pure." It smells sickly and nauseating, reminding me of decomposing horse's urine. Certainly it is not invigorating. From one mine, in cold weather, one can see this as a dirty brown-coloured vapour as well as smell it.

Yours, etc.,

H. S. ELWORTHY.

DEAR SIR,

I gladly avail myself of the invitation to comment on some of the points raised in Dr. Elworthy's letter. It has been demonstrated that the incidence of a yellow or "yellowish" light on a violet ground reflects a white-rose tint and on indigo-blue ground a white tint. Assuming that the colour of the coal face is blue-black the incidence of light from a yellow-tinted electric lamp bulb would be of a whitish character, and this appears to be desirable.

I have found that the miners are satisfied with the 1 candlepower light of an electric lamp and I suggest that a 1·5 candlepower lamp reduced by a yellow or orange tinted glass to an effective 1 candlepower throughout the shift will afford a safe mean between the 2 candlepower bright spot of an electric lamp and the 0·3 candlepower average of the ordinary oil lamp.

I quite agree with Dr. Elworthy in his preference for the carbon filament lamp as regards colour, but such lamps are not so efficient as the tungsten filament lamps and their use would necessitate a heavier battery. Messrs. Mills and Son, of Newcastle-on-Tyne, recently introduced, for use in the "Joel-Fors" lamps, bulbs with the metal filaments made in a close spiral, but the miners object to the spot of light, and Messrs. Mills are accordingly having the spiral filaments extended into a bow-shaped curve, giving a more extensive illuminating surface, so as to meet the miners' objection.

As regards practical tests in coal mines of yellow tinted glass bulbs in electric miners' lamps, at a recent interview with the Home Office Miners' Safety Lamp Committee I was informed that the matter is receiving their attention.

Yours, etc.,

HENRY F. JOEL.

THE ARTIFICIAL LIGHTING OF CHURCHES.

SIR,

From the discussion on Church Lighting which followed upon Mr. Darch's paper on April 20th, the most disputed point would appear to be the desirability of much or little light. Frequent reference was made to "Dim Religious Light," and also to the tendency to sleep which is sometimes revealed. As the decision of this question by authorities concerned may influence the progress of adequate lighting in our churches, may I offer an opinion regarding these phenomena?

Just as the eye is attracted towards the brightest light it can see, so is the attention arrested by the object from which the light comes. In surroundings only faintly lighted by a "Dim Religious Light," there are no bright lights to attract the eye and to distract the mind. Prayer, particularly when not uttered audibly, is the very essence of concentrated thought, and it is because of the absence of any distraction, due to easily visible objects, that the "Dim Religious Light" genuinely and undeniably does assist in this concentration. Similarly the custom of covering the face with the hands prevents the mind from being distracted by the sight of any object.

On the other hand, when a sermon is being delivered or a lesson read, the mind of the congregation is centred upon the preacher or reader, and to enhance this concentration it is highly desirable that the preacher or reader should be in a light such as will make him conspicuous and easily visible. It would here be desirable for the general illumination around the congregation to be of low intensity, except that during the lesson it is frequently necessary to follow the reader in a Bible, especially in such churches or parts of a church where audibility is not good. This difficulty might be met by increased local lighting beneath galleries and other places where it is not easy to hear.

The tendency to sleep, which was also referred to by several speakers, would also be explained by the lack of concentration when the preacher is not easily visible and his expressions cannot be seen. The effort required to hear in such cases is generally at the expense of concentration of thought on the sermon itself.

During other portions of the service when it is necessary to read, it must be borne in mind that the concentration which is necessary in a dim light for the reading of the words themselves is prejudicial to the realisation of the meaning of what is being read.

Yours, etc.,

G. K. FLETCHER.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Elements of Electrotechnics. By A. P. Young, O.B.E., M.I.E.E. (Sir Isaac Pitman and Sons, Ltd., London. 1920. *pp.* 348. *Figs.* 179. *7s. 6d. net.)*

THIS is an addition of the series of works issued by the above firm which aims at dealing with technical subjects in a clear and logical manner. On this occasion the book is written with a view to informing those who wish to be conversant with the technicalities of the subject. It is, however, clearly written and well illustrated and should prove useful to students. The earlier chapters deal with fundamental principles, and the author then passes on to such matters as electrolysis, magnetism, measuring instruments, insulating materials, and electric generators and motors. Principles are illustrated by explanations of practical developments such as electric furnaces, meters, sparking plugs, traction problems, etc. We notice that the author professes only to deal incidentally with alternating currents. This strikes us as an omission that might be rectified in a subsequent edition in view of the important part played by alternating current machinery at present and its probable greater extension for transmission purposes in the future.

The Compulsory Adoption of the Metric System in the United Kingdom. (Report submitted by the Metric Committee of the Conjoint Board of Scientific Societies).

THIS comprehensive report analyses the views of a number of scientific societies on the above question. The Committee favour the use of the metric system in all scientific work and its introduction in industry, but are not prepared to recommend its being made compulsory for the retail trade of the country.

The Empire Municipal Directory, 1920-21. *(The Sanitary Publishing Co., Ltd., London. 38th Annual Issue. pp.* 269, *vi. 7s. 6d. net).*

WE have before us the thirty-eighth annual issue of the above publication, which affords a complete guide to municipalities, corporations, etc., and their officers throughout the kingdom, and should continue to prove of great value to all who have to do with municipal affairs. As in former years, special articles are contributed dealing with such problems as roads and road-making, water supply, sewage disposal,

fire prevention, housing and town planning, etc., and we observe that the review of street-lighting has been brought up to date. We are glad to record the appearance of another edition of this useful book of reference.

Education and Training for the Electrical and Allied Engineering Industries. (Report issued by the Education Committee of the British Electrical and Allied Manufacturers' Association. Edwin Arnold, London. 1920. *pp.*, 64.)

THE Committee was formed during the war "to consider the whole subject of technical education in the electrical and allied industries and to suggest a uniform system." The Council, in acknowledging the services of the members of the Committee, pays a special tribute to the zeal and energy of the Chairman, Mr. A. P. M. Fleming, who is well known as an indefatigable worker in this field.

Throughout the report a distinction is drawn between "education," in its wide sense, and "training," which applies more particularly to training in the shops. The proposals involve a classification into trade apprentices, engineering apprentices, student apprentices, and research apprentices, but it is suggested that gifted student youths should be given opportunities of qualifying for promotion to a higher grade. Stress is laid on the continuation, in suitable schools, of primary education—in itself inadequate. The duty of the firm to care for the welfare and instruction of apprentices, instead of (as too often happened in the past) leaving them to "pick up" knowledge, is clearly indicated. One step advocated is the appointment of apprentice supervisors, who would give an eye to their charges by supervising games and recreation, etc. It is remarked that scholarships have been too exclusively bestowed on those entering the so-called learned professions, and that they are too often regarded as honours to be won, irrespective of the means of the applicant or his parents. The report is concluded by a series of recommendations which members of the Association endorse.

We are glad to note this evidence of earnest study of a difficult subject, and the desire of this influential Association to establish a suitable system of education for apprentices which we hope will eventually become general throughout the country.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

We are informed that Professor Sir John Cadman, K.C.M.G., D.Sc., Mr. W. B. Hardy, Soc.R.S., and Professor Sydney Young, D.Sc., F.R.S., have been appointed to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

The Department of Scientific and Industrial Research has established four sub-committees to assist the Radio Research Board in various investigations. Sub-committee A, on the Propagation of Wireless Waves (Chairman, Dr. E. H. Rayner, Sc.D.); sub-committee B, on Atmospherics (Chairman, Col. H. G. Lyons, D.Sc., F.R.S.); sub-committee C, on Directional Wireless (Chairman, Mr. F. E. Smith, O.B.E., F.R.S.); and sub-committee D, on Thermoionic Valves (Chairman, Professor O. W. Richardson, D.Sc., F.R.S.).

We have also received from the Department a list of sixteen Research Associations which have been approved as complying with the conditions laid down in the Government scheme for the encouragement of industrial research, and have received licences from the Board of Trade. Seven more have been approved but are not yet licensed, and four industrial organisations are engaged in preparing memorandum and articles of association. Others are taking the preliminary steps towards formation.

IRON AND STEEL INSTITUTE.

An invitation has been extended by the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire for the Autumn meeting of the Institute to be held in Cardiff at the South Wales Institute of Engineers.

The proceedings will open on Monday, September 20th, and will terminate on September 24th. A list of thirteen papers is announced and visits have been arranged to a number of important works. Further particulars may be obtained from the Secretary of the Institute, 28, Victoria Street, London, S.W.1.

INDEX, July, 1920.

TOPICAL AND INDUSTRIAL SECTION.

[The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

GENERAL ELECTRIC CO., LTD.

Annual Meeting.

At the Annual Meeting of the General Electric Co., Ltd., on July 13th, Mr. Hugo Hirst, the Chairman, gave a summary of the development of the Company during recent years, explaining various reconstruction steps of post-war reconstruction, and alluding specially to the assistance rendered by the late Sir Edward Holden in connection with financial arrangements. Reference was made to the acquiring of the works of Messrs. Fraser and Chalmers and other important engineering projects. We are interested to observe that the Company hopes before long to double the output of electric lamps, as new buildings for this work at Hammersmith are approaching completion. The glass works at Leamington have also been largely extended. The carbon works apparently again present a difficult problem following the slackening of war requirements, but an interesting development has been the continued progress of the works for producing lamp-black, which is needed by various industries.

In the latter part of his address Mr. Hirst pointed out the unfortunate effects of the Excess Profits Tax, which allowed inadequate funds for development and interfered with many steps for the benefit of employees. He concluded by emphasising the fact that the key-note of future industrial prosperity lay in the improvement of present inefficient methods of production and a general reduction in the cost of commodities. Therein lay the safety of the worker as concerns continuity of employment; for if prices soared higher and higher only the few could buy, and the world's demand would be so curtailed that there would be over-production.

VICKERS, LTD.

Messrs. Vickers, Ltd., Broadway, London, S.W.1, inform us that they have opened a depot for Wales and the South-West of England at 43, Park Street, Bristol, at which address they will be glad to receive inquiries for their products.

TOUCHBUTTON HOUSE.

Exhibition of Magicoal Fires and other Electrical Apparatus.

At Touchbutton House (86, Newman Street) visitors may see a highly interesting exhibition of special electric heating devices, including the "magicoal" fires, devised by Mr. H. H. Berry. A number of representatives of the Press were recently present by invitation to view the exhibits. Mr. Berry, in a short address, remarked that the use of coal appeared to have originated in 1256, when Henry III. granted a charter to the inhabitants of Newcastle to dig coal in the vicinity of that town. In 1306, however, Parliament passed a Bill prohibiting the use of coal as fuel on account of its alleged noxious fumes, and domestic coal was not used in London until 1561.

At the present day we are less concerned with the presumed noxious fumes, but we are coming to recognise the inherent inefficiency of the coal fire, as illustrated in the recent interim report of the Ministry of Health's Smoke Abatement Committee. The affection for the coal-fire is largely due to the pleasing appearance of the dancing flames and glowing coal. Mr. Berry has accordingly sought to imitate this effect in the electric magicoal fire. The grate is filled by a mixture of crude silicon, resembling black and glowing coal, amidst which heaters and lamps are mounted to give the desired luminous effect; further, ascending currents of air, agitating small mica vanes, interrupt the light in such a way as to produce the effect of dancing flames. The material occupying the grate and producing this optical illusion produces only about one-tenth of the heat; the greater part is commonly derived from electric heaters let into the fireplace in front of the grate, and mounted in a metal framework on which water can be boiled, bread toasted, or dishes kept warm if desired. It is interesting to notice, however, that Mr. Berry is applying the same idea to gas and petrol air gas fires.

At the exhibition at Touchbutton House these special fires have been arranged in a number of reconstructed famous fireplaces of historic interest, dating from different periods, and many of them delightful works of art. In the various rooms are also to be seen panelling, tapestry and antique furniture of great value. Another development is the use of braziers, which are replicas of ancient designs, carrying the luminous fire in the bowl and electric heaters concealed in the base of the pedestal.

In the basement demonstrations are given of various electrical heating and labour-saving devices, as well as Mr. Berry's system of central heating, to which the electrical fires described above form a useful addition.

ALL-NITE-LITE TRANSFORMERS.

There are many situations where very little light is needed, but for a long time, *e.g.*, in night nurseries or passages, porches, and in the bedrooms of sick people where a "night-light," burning continuously throughout the period of darkness, is necessary. Obviously an ordinary electric incandescent lamp, running direct on the supply voltage, is wasteful in such cases. All that is wanted is to produce a dim light, but sufficient to enable persons to make their way about a room and dissipate the complete darkness.

For such purposes the B.T.H. "All-Nite-Lite" transformer has distinct advantages. It consists of a small step transformer equipped at one end with a bayonet adaptor to fit an ordinary lamp-holder, and at the other end a miniature lamp-holder to take a 6-volt 3 candle-power lamp. The overall length is only 3½ ins. Two types are available, suitable respectively for use on a.c. circuits of from 100-150 or 200-250 volts. At ordinary supply rates it is calculated that this small light can be burned for from 40-50 hours at a cost of only 1d. In addition to the uses indicated above, it is suggested that such miniature lighting units might well be used in the entrance hall, not only as a convenience to late home-comers, but as a possible deterrent to burglars. Even in the winter the cost of using such a light, burning, say, from bedtime to 8 a.m. in the morning, would not exceed about 1d. per week.

FALK, STADELMANN AND CO., LTD.

Annual Staff Outing.

On Saturday, July 31st, the Head Office of Messrs. Falk, Stadelmann and Co., Ltd., had an outing to Rye House, Hertfordshire, where they were conveyed by a fleet of 30 motor-buses and entertained by the Directors to dinner and tea. Mr. Max Falk, replying to the toast of "The Firm," which was proposed by Mr. L. J. W. Laidler, recalled that the first of the series of annual outings took place some thirty years ago, when the guests numbered 30, as compared with 680 on the present occasion. The day was occupied in impromptu sports, boating, dancing, etc., and fortunately the weather was fine.

8

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

Special Problems in the Lighting of Industrial Machinery.

The introduction of powerful and efficient types of lamps has had a considerable influence on Industrial Lighting during recent years. Methods formerly in use involved the suspension at regular intervals of lights of relatively small candlepower. The method of hanging a large number of lamps at a low level has the drawback that it prevents the manager having a clear view of the room, and there is also the difficulty that with metal reflectors the upper part of the room may appear unduly dark. With the coming of more powerful sources of light there has been a strong tendency towards what is known as overhead general lighting. The lamps are mounted high up direct on the ceiling or girders. They are so placed as to flood the room evenly with light, and leave a clear view from end to end of the workshop.

There are many operations, particularly those comprising fairly simple operations, where this method has undeniable advantages. It is particularly useful when operators work side by side on identical operations, all requiring the same form of lighting. It has also the advantage that positions of benches and machines can be altered without the lighting being much changed. It must not, however, be assumed that the method has a universal application. For example, experience seems to show that when one is dealing with very dark materials, and accordingly exceptionally high illumination is needed on the work, some form of supplementary local lighting is necessary. With local lighting by well-shaded lamps one can bring the light nearer the work and secure the required illumination with a relatively moderate consumption of gas or electricity. Another

advantage is that the brightness of the materials worked upon can be made at least as great, or possibly greater, than that of the surroundings, thus making it easy to concentrate attention on the work. On the other hand if a room is flooded with light the surroundings may be very much brighter than the material, and the latter therefore appears to be inadequately illuminated, even though the number of foot-candles used may be considerable.

Other special cases arise when care must be exercised to prevent inconvenient reflections off the polished surfaces of working material. If general lighting is adopted, it is almost impossible to avoid some of the light being reflected direct into the eyes of the workers, rendering it difficult for them to see what they are doing. The local lights, on the other hand, may be so adjusted that the light comes from the proper angle, and such reflection is avoided. Moreover, we have cases where the direction from which the light comes is highly important—for example, in preventing the formation of inconvenient shadows from fine edges of tools, or projections from the material.

There are also processes of work, where light coming from a very oblique angle is necessary in order that the texture of the material may be distinguished. When a room is occupied by many different forms of machinery it will usually be found that some degree of local lighting suited to such machine is necessary; but in all such cases care must be taken to supplement the local lights by moderate general illumination, so as to prevent excessive contrasts.

But the cases in which general lighting proves least effective are probably those in which one has to deal with closely-spaced, highly-complicated machinery. As is often the case, for example, in the textile industry, the overhead lights may effectively illuminate the gangway and the upper parts of the machines, but projecting parts of the machine leave other really essential parts in more or less dense shadow; it would seem that in these cases some form of special supplementary lighting at particular points must be provided.

All these problems require to be carefully worked out on the spot, when one can study the machine and its operation, and ascertain the needs of the worker. Even so it may be found that existing procedure in the design and spacing of machinery makes it extremely difficult to provide the ideal form of lighting. It is much to be desired, therefore, that the manufacturers of such machinery should appreciate the fact that they have to be used by artificial light as well as by daylight. It has often been asserted that a building should be specially designed to enable artificial lights to be installed at convenient points; when the lighting expert is called in after the completion of the building he is greatly handicapped in his task of providing good illumination. This is exactly what occurs when he is asked to illuminate machinery which has been designed and placed in such a way as to make the artificial lighting an exceedingly awkward problem.

In many cases there are alternative ways of designing machinery, both equally good so far as their technical operation is concerned, but very different as regards the problem of illumination. A little forethought would make a great difference to the lighting expert's task. As a result of consultation with the lighting expert he could often arrange to incorporate in the design sockets, brackets, etc., which would enable the ideal condition of lighting to be obtained quite easily and render the manipulation of lamps and lighting accessories quite safe when the machinery comes into actual use.

Gaseous Conductors as Sources of Light.

While, as is well known, the great majority of our artificial illuminants depend on the emission of light from incandescent solids, great interest attaches to the group depending on luminescing gaseous conductors of electricity. Of these the most familiar in this country are probably the mercury vapour lamps, while flame arc lamps also depend to some extent on luminescing metallic vapours. There are, however, also the illuminants depending on the use of the permanent gases in a rarefied state—a branch of work which is mainly identified with the work of Mr. D. MacFarlan Moore.

In this issue we are dealing with a paper by Mr. Moore surveying the whole progress of development in this field. It is a record of persevering effort which has already had some highly interesting results. The so-called Moore system of lighting, using ramifications of tube containing such gases as nitrogen or carbon dioxide, gives rise to a pleasing luminous effect, the mild brilliancy of the source and good diffusion of light being particularly notable. The method, however, involves the use of high pressures amounting to several thousand volts obtained by the use of transformers on an alternating current supply. The long length of tube is not always convenient, though in certain special cases, notably the colour-matching, CO_2 tubes, very compact and portable units have been designed.

The introduction of neon gas, which luminesces with a much higher intrinsic brilliancy, permitted the use of relatively short lengths of tube, and it is suggested that these lamps may play an important part for advertising and spectacular purposes. The colour of the light, a vivid orange, is, however, hardly suitable for ordinary purposes of illumination, although there may be special cases (*e.g.*, luminous signs and signals) where it is actually advantageous.

After tracing these various developments, Mr. Moore describes the latest advance, which may have interesting applications, namely, the making of a small neon vapour lamp which requires no transformer and can be inserted into an ordinary incandescent lamp socket on a 220 v. circuit. The light is a soft yellow glow appearing at the negative electrode, and giving a light of about one candle. The consumption of the experimental lamps described in Mr. Moore's paper is at present high, *i.e.*, about 15 watts per candle, but as the lamp is still in its initial stages there is a good prospect of improvement.

An efficient form of lamp of this kind, capable of being used on any ordinary electric supply circuit would have distinct advantages. For example, in lighting passages, for "night-lights," etc., and in cases where only a little light and a small consumption are desirable.

We notice that in Germany neon lamps consuming only 5 watts on 220 volts are now being produced for use in such circumstances, and there has also been further progress in the form of high candlepower neon lamps suitable for advertising work. Developments in this field will be watched with great interest. It may be that in the future vapour lamps of various kinds employing the principle of luminescence will play a more important part than at present in illuminating engineering.

The Lighting of Squares and Public Places.

Nearly two years have elapsed since the cessation of hostilities and much of the temporary lighting arrangements occasioned by the war have given place to normal methods. In London, at all events, public lighting has returned very nearly to the conditions existing before the war. In commenting on this subject some time ago we expressed the hope that authorities would not be content to return to the identical pre-war arrangements, but would take the opportunity of making improvements. At present the chief changes effected relate to the substitution of different lamps. Gas-filled incandescent electric lamps, for example, have been introduced widely in place of the old arc lamps. We are glad to see that in a number of cases the latest forms of lanterns, specially designed with a view to the proper distribution of light, have also been installed. In other cases the new lamps have at present been inserted in existing lanterns, doubtless owing to limitations of expenditure or difficulty in securing an adequate supply of entirely new lighting units. In such circumstances one cannot expect to get the best results, and much of the advantage of the change is lost, and we, therefore, hope that such emergency methods will give place to more scientific ones as opportunity affords.

No doubt present practice is often dictated by economy and by the necessity of making an immediate improvement in the lighting conditions, without waiting for the new designs and ideal methods. But when plans can be made some time before the alterations are effected, and especially when important structural changes are made in streets and squares, the lighting should undergo thorough revision, and we hope that this will be done more generally as soon as financial considerations permit.

Such an opportunity appears to be afforded by the scheme for improving the prospect through the Admiralty Arch, Trafalgar Square, which was in contemplation before the war and is now being carried into effect. The plans of the L.C.C. will secure, what has previously been lacking, a clear view through The Mall to the Victoria Monument and will do something to improve the symmetry of the square. We are glad to observe that some improvements have recently been made, which have the effect of diminishing the disparity which formerly existed between the lighting of the upper section of Whitehall and that of the lower portion of this important thoroughfare. There seems to be an opening for some form of special lighting, possibly by concealed methods, of the Admiralty Arch. This would guide the eye towards the entrance to the park so as to afford a pleasing prospect by artificial light. If, in addition, concealed lighting could be applied to reveal the white surface of the Victoria Monument, this would provide, what is at present lacking at night time, a striking termination at the distant end of The Mall.

We mention this as one typical case where slight adjustments in lighting would make a great difference to the appearance by night time. There are also opportunities for more spectacular lighting, not necessarily involving any greater expense, at the Marble Arch gate. The erection of the permanent Cenotaph would also be a fit subject for concealed lighting. We are fully aware of the need for economy in lighting, but we think that in such a case as this the small expenditure on special illumination would be amply justified. When so much trouble has been taken in the design of this memento it should surely be rendered visible by night as well as by day.

L. Gaster.

GASEOUS CONDUCTION LIGHT FROM LOW VOLTAGE CIRCUITS.*

By D. McFarlan Moore.

Light can be produced electrically in various ways, *i.e.*, by agitating either solids, liquids or gases. In the incandescent lamp a solid filament is the light-giving medium, but many lamps have been devised in which gas is brought to a luminous state by the passage of an electric current. Natural electric lights of this description are the aurora and lighting. In 1870 Hawksbee produced light by gaseous conduction in a rotating glass sphere. Later Geissler operated small tubes from an induction coil. In 1879 Crookes modified such tubes in various ways, obtaining high vacua, and in 1891 Tesla delivered his famous lectures on "High Voltage and High Frequency."

The writer first became interested in the possibility of constructing a "filamentless" lamp in 1893, and during the subsequent 26 years this idea has been steadily pursued. The first attempt in 1893 to obtain light without a filament on 220 volts was unsuccessful although all known gases were tried. The prediction was then made that progress would only result through the discovery of some new gases whose existence was indicated by gaps in the table of the periodic law for elements—a prediction afterwards verified by the discovery and use of neon gas.

In 1894 the induction coil was resorted to in order to obtain a high voltage discharge through gaseous mixtures, and subsequently the vacuum vibrator on d.c. Bulb lamps were filled with the negative glow light. In 1896 seven feet vacuum tubes with external electrodes replaced the bulb lamps. The method was applied to the meeting hall of the A.I.E.E., and afterwards in the celebrated "Moore Chapel."

* Abstract of a paper read before the American Institute of Electrical Engineers.

The first 220 v. d.c. tubes, started from a higher potential, were next made. The anticipated discovery of neon was announced in 1898, but even samples of it were then impossible to obtain in America. The other rare gases, argon, helium, etc., were discovered in rapid succession.

The "long tubes" (about 100 feet) appeared in 1902 and were improved by the substitution of internal electrodes. In 1905 the special generator hitherto employed was dispensed with, static transformers incorporated in the lighting system being used, and brilliant effects were obtained by the use of nitrogen gas. The next step was the introduction of the electro-magnetic feed-valve, whereby the life of the tubes was raised to 10,000 hours. The long-tube system is now well known. It has the great advantage of generating light at a low intrinsic brilliancy, and in a diffused form. In 1910-11 long tubes in the form of portable artificial daylight windows using CO_2 were introduced, and in 1913-15 several types of small tube lamps were made for colour-matching purposes. Simple neon tubes operated from transformers were designed and made in many varieties. Some of these were equipped with screw base lamp bases, enabling them to be screwed into any ordinary lamp holder. Such lamps consume 13 watts and have been run without change for 10,000 hours. In the autumn of 1916 there was exhibited the first portable and commercial neon tube outfit of high intensity and efficiency operated from a step-up transformer. The tube was in the shape of a hair-pin and used a gas-column 101 in. long and $\frac{7}{8}$ in. diam. This lamp had a specific consumption of 0·74 watts per sph. candlepower. Even this high efficiency may, it appears, be improved upon by using purer neon gas (*i.e.*, neon gas that does not contain

25 per cent. of helium and other impurities). Such lamps have considerable possibilities for advertising and spectacular work on account of the vivid red colour of the light.

Various alternating current lamps were made to operate on 220 volts (alternating current) without any transformer. But they needed a momentary higher voltage to start the discharge through the column of gas. The length of gas column (about 3 in.) in these lamps is too great to permit 220 volts to start the discharge; but it can be maintained on this voltage once it is started.

Interest centres chiefly in the attempt to produce a lamp which can be started on low voltages on cold electrodes and without the use of a momentary high potential. The lamp is still in the experimental stage, but has interesting possibilities, as it seems likely to fulfil, ultimately, the ideal of a gaseous conductor lamp without auxiliaries for low voltage circuits. There are indications that the final solution of the problem of obtaining lamps vastly more efficient than at present available lies in the use of a gaseous conductor whereby it may be possible to reduce the energy required for the production of a given amount of light to one-tenth the present value.

The lamp in its present form resembles an incandescent lamp in outward form. Four aluminium electrodes, each 6 in. long, $\frac{5}{8}$ in. wide, and $\frac{1}{16}$ in. thick, are mounted on a 3 in. straight-sided bulb about a common centre. The opacity of the solid radiators is objectionable, and yet the effect of a solid radiator is approached by radiators made of very small meshed netting. An effort was made in designing this lamp to take advantage of every factor favourable to minimum voltage so that it would operate on 220 volts or less. The required potential is least for the negative glow, and all the light from this form of lamp is derived from this region of the discharge, not from the positive column as in all the long tube lamps.

Hitherto it has been assumed that the light yielded by the negative glow in any vacuum tube discharge is so small as to make it entirely negligible. An ordinary long tube discharge consists of (a) next to the cathode the short first dark space, (b) the short and not bright negative glow, (c) the short second dark space, and (d) the long brilliant positive column extending to the anode. But in this form of lamp the positive column is eliminated and practically all the light comes from the negative glow, which appears in the form of a "velvety" corona of yellowish light spread over the entire surface of the electrodes, and also a uniform radiation throughout the entire interior of the bulb.

On 220 v. a.c. circuits the lamp takes from the line about 0·11 amperes and 21 watts, but of this amount 3·6 watts at 33 volts is consumed in an ohmic resistance about 1 in. long placed in the skirt of the lamp base. The finished lamp will probably require no material resistance, though at present such a resistance affords a convenient method of adjusting the total watts consumed. The specific efficiency of this particular lamp is low. It consumes 17·4 watts and gives approximately 1·16 mean sph. candlepower, thus consuming about 15 watts per candle. The most important problem is how to eliminate the emission of heat waves and improve the luminous efficiency. If the line voltage is decreased to about 135 volts with this lamp it is suddenly extinguished. The neon used has a helium content of 25 per cent., and, when sealed off, the pressure of the gas is 3·5 mm. The bulb-temperature is about 40°C. The colour of the light is yellow.

Important factors in the design of this lamp are:—

(1) The attempt to use a gaseous conductor of maximum conductivity.

(2) Electrodes that are subdivided and of as large a total area as possible.

(3) A gas column (discharge gap) as short at possible.

(4) The plane of the electrodes of opposite polarity placed parallel to each other.

(5) The length of the radiator electrodes greater than the gas column and perpendicular to it.

Cathodic disintegration is practically nil with the minimum value of cathode fall. It is greater at low gas pressures and increases with the square of the

current. It appears to be due largely to occluded gases, especially hydrogen. Such gases may be removed by heating the electrodes. Bulb blackening is less with aluminium radiators than tungsten, nickel, copper, etc. Iron radiators combined with fluorescent coatings offer promise. The exceptional luminous efficiency of neon makes it unique as a luminescing medium, and it is an excellent example of elective emission. Its great scarcity until recently made progress difficult, but it can now be bought in quantity and of a high degree of purity. It is interesting to note that the colour of the light yielded by the negative glow is distinctly different from that of a positive column. The former has a light so reddish that it would be objectionable for many purposes, but the negative glow consists of yellow light. It has no blue, violet or indigo lines and few infra-red rays. It is four times better as a light-producer than the yellow white light of helium or the violet of xenon, both of which emit many infra-red rays.

Some of the chief conclusions that may be drawn from existing results are as follows :—

(1) The efficiency of these lamps is about the same whether operating on a.c. or d.c. circuits.

(2) On a.c. circuits the efficiency is the same over a wide range in voltage.

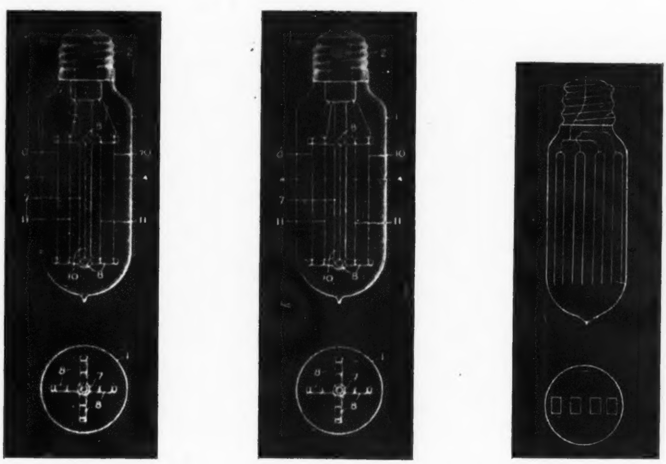
(3) Efficiency also remains the same on a.c. circuits for a wide range of candlepowers.

(4) The candlepower (mean spherical) varies approximately with the watts consumed on either a.c. or d.c. circuits.

(5) Lamps having reasonably pure neon are not so efficient as those in which gas impurities make the colour of the light whiter.

(6) The performance of the lamps is not sensibly affected by wide variations in the length of the column or gap.

(7) The same lamp equipped with the same resistance and operating at the same voltage takes a considerably higher line wattage on a.c. than d.c., which is doubtless due to the light radiating area being double.



Types of low voltage neon "negative-glow" lamps suitable for use direct on 220 volts.

(8) The candlepower is greater with radiators of large area.

(9) The power factor of these lamps is about 85 per cent.

Many different forms of lamps of this type have been produced. The chief aim must be to produce a brighter lamp. At higher voltages the production of greater candlepower is more feasible, and consequently it might be better first to develop a lamp suitable for 500 v. circuits.

THE DEVELOPMENT OF LOW-VOLTAGE NEON LAMPS.

As a supplement to Mr. Moore's historical account of gaseous conductors as sources of light, appearing on the previous pages, it is interesting to note that the development of low-voltage neon lamps in Germany appears now to have reached a practical stage. In a recent issue of *Licht und Lampe* it is stated that these 220 voltage neon "glimmlampen" are now being produced to consume only 5 watts, whereas the lowest consumption attainable with ordinary tungsten lamps on a 220 voltage supply circuit is 20 watts. The lamps fit into an ordinary lamp-socket, and yield a "glimmer" of light, which is, however, enough for certain special purposes (night lights, pilot lights, etc.).

Special interest attaches to these lamps on account of the possibility of making the enclosing glass vessel containing the gas assume different forms. For example, the lamps are being designed for use in small advertisement signs, the gaseous column of each lamp being formed in the shape of a letter. It is hoped that in such cases the ultimate consumption per letter will not exceed 2–3 watts.

Particulars are also given of high candlepower neon lamps, which as Mr. Moore has explained, depend on a different principle. These lamps can be connected direct to a 220 voltage continuous current supply. They require a steadying series resistance and a special automatic starting device, the latter only coming into operation at the moment the lamp is switched on. These accessories are enclosed in a separate box. The standard type of lamp is stated to yield 400 candles (Hefner) and to consume 0·5 watts per candle.

RECENT PROGRESS IN SEARCHLIGHT MECHANISMS.

As is well known the war was responsible for a number of modifications in the design of searchlights, particularly in respect of the observation of aircraft. In *Elektrotechnik und Maschinenbau* A. Zimmerman recently described some developments in connection with control from a distance. It is now generally recognised that the observer controlling a searchlight should not be located beside it, as in this case his view of the distant illuminated object is more or less blurred by the intervening luminous haze of the beam. The observer may take up a more distant position and convey orders by telephone; but there are now available methods, which the author describes, enabling the observer himself to operate the movements of the projector from a distant observation-station.

As regards searchlights for aircraft work a notable step has been the rearrangement of the apparatus swinging the barrel. Formerly the usual control enabled an upward lift of the beam of 60° and a depression below the horizontal of 30°, combined with a rotation about a vertical axis of approximately 360°. This obviously left an upper region of 30° on either side of the vertical which cannot be reached by the beam. Nowadays the complete 180° above the horizontal can be covered, thus enabling the beam to be directed on any object in the sky.

Another way in which this vertical inclination of the beam can be attained is by the use of an inclined mirror, which is manipulated instead of the barrel. This device appears to have been superseded by the motion of the barrel for land work. The author, however, describes a method of applying the inclined mirror to ships. The searchlight is mounted in the base of a hollow mast. A controllable inclined mirror is located at the top of the mast so as to reflect the beam, directed vertically upwards, at any convenient angle.

MEASUREMENTS OF GLARE.

THE problem of devising an apparatus for measuring "glare" produced by sources of light has often been discussed. One difficulty involved is the discrimination between several different effects, commonly classed under the heading of "glare"—for example, there is the sense of discomfort, the tendency to make it difficult to *see* things and the after-effects of glare, which may not be exactly the same thing. In any case it is clearly difficult to measure physiological sensation by any form of physical instrument and the measuring device should be based on the actual impression of the eye.

In a paper before the Illuminating Engineering Society (U.S.A.), Mr. Ward Harrison recently described some simple tests on glare. The apparatus consisted of two adjacent boxes with black interiors. One of these was occupied by the source to be studied, the other by a ground glass disc, the back of which could be lighted by a series of lamps, controlled by a rheostat. The observer was asked to adjust the resistance until the disc appeared to produce the same impression of glare as the source examined.

On the whole the judgments of observers seem to have agreed well, and it was found possible to group the source studied in four classes regarded as good, passable, just passable, and intolerable (*i.e.*, unsuited for general use). The results, however, did not entirely confirm anticipations. For example, a clear bulb 100 candlepower gas-filled lamp was not considered as objectionable as a lamp of double the candlepower in an opalised globe, although the intrinsic brilliancy of the latter was very much less.

It is generally agreed that glare is influenced by three main factors, namely (1) the intrinsic brilliancy, (2) the total flux of light directed to the eye, and (3) the degree of contrast between the source and its background. It is worthy of note that enough light was allotted to the interior of the box to give a background with a brightness of 0·6 millilambert (0·5 apparent lumens per sq. ft.) in each case. Possibly with a completely dark background the judgment might have been different. No doubt the distance from which the source is viewed is also an important factor. So far as they go, however, the tests suggest that the total flux of light entering the eye is at least as important as brightness. It is suggested as a criterion of glare for bare lamps viewed at a considerable distance that it is more reasonable to specify tendency to produce glare in terms of the total light emitted from an area of, say, one square inch, rather than in absolute brightness.

THE PROTECTION OF THE EYE IN WELDING OPERATIONS.

IN a paper read at a recent meeting of the British Acetylene and Welding Association, Mr. R. R. Butler gives an interesting survey of available information on the nature of the injuries caused to eyes in welding operations, and an analysis of the various kinds of glasses used for protective purposes. He points out the importance of this matter to the employer as well as the welder. Apart from severe inflammation of the eyes, there is a species of "dry-eyed cloudiness" experienced at the end of a long day's labour which indicates fatigue and may occasion bad work. Many types of protective glasses are available, but there is no official publication in this country, equivalent for example to the bulletin issued by the Bureau of Standards in the United States, giving details of the merits of these varieties. The relatively high cost of manufacture of useful protective optical glasses is apt to influence purchasers unduly, and there is a danger that cheaper varieties, affording more or less inadequate protection, may be selected.

It is accordingly suggested that the British Acetylene and Welding Association should make itself responsible for the issue of some form of certificate which would furnish a guarantee that the glasses to which it applied did convey adequate protection.

GAS-FILLED LAMPS WITH WHITE GLASS BULBS.

AT the opening meeting of the Illuminating Engineering Society last year Mr. J. W. Elliott exhibited a type of half-watt lamp, the bulb of which was made entirely of white or opal glass, thus completely obscuring the filament, and giving rise to a soft and pleasing light.

In the *General Electric Review* (U.S.A.) Mr. E. A. Anderson gives some particulars of lamps of this kind developed in the United States. The "White Mazda Lamp" is made in the 50-watt size, and has an output of approximately 450 lumens. A feature of the new lamp is the absence of any tip, which results in an appreciable reduction in lamp breakage, and gives a conveniently smooth surface. Frosting the bulb has been recommended in the past as a means of reducing the brightness of gas-filled lamps, but this has the drawback that such bulbs tend to collect dust and dirt more quickly than the clear bulbs, and are more difficult to clean. The smooth white glass surface does not collect the dust in this way.

It is stated that the brightness of the bulb is about 13 candlepower per square inch at the brightest point, which is of course a relatively low intrinsic brilliancy. The distribution curves of such lamps show, as might be expected, a greater end-on candlepower than is the case for clear bulb lamps.

COMPARATIVE DATA ON LIGHT OUTPUT.

Type of Unit Tested.	Output in per cent. of Bare Lamp Output.	
	Mazda "B."	White Mazda.
Glass bowl, 6" diam. ..	85·4	87·6
Glass bowl, 7" diam. ..	84·8	86·1
Enclosing unit	77·5	76·4
Enamelled-steel bowl ..	60·5	61·3

The accompanying table shows the results obtained with various types of reflectors. It will be observed that the loss of lights is not of great consequence, taking into account the compensating advantages of diminished glare and better distribution of light below the horizontal.

OPPORTUNITIES FOR THE ILLUMINATING ENGINEER IN THE CINEMATOGRAPH INDUSTRY.

IN view of the reference made by Captain Barber to this subject in his recent paper,* it is of interest to note that Mr. E. L. Bragdon, in a paper before the Illuminating Engineering Society in the United States, has likewise emphasised the need for the illuminating engineer in cinema work. The two chief fields for his ingenuity appear to be in arranging lighting for the auditorium and in the design of the projecting system. The artificial lighting of many of the smaller theatres is considered very bad. Success is attained by co-operation between the lighting expert and the architect, who too often installs some form of moulding or decoration at the very point where an indirect unit should be mounted, or makes use of bracket lights at the sides when concealed lamps in niches would give a much better effect. Three rules in arranging the lighting are: (1) Keep as much light as possible away from the screen, (2) present as little contrast as possible to the eyes of the audience when viewing the picture, and (3) make the transition from sunlight or outside artificial light to the theatre as gradual as possible. The illumination in a theatre should be greatest at the back and gradually diminish as one approaches the screen.

As regards projectors, it is pointed out that in general 25 per cent. of light reaches the condenser, 80 per cent. reaches the film, and 75 per cent. reaches the shutter, which again diminishes the light by 50 per cent. Consequently only 0·8 per cent. of the original light is actually used on the screen. In the author's words, "there are too many middlemen and each is a profiteer." Here, therefore, is a fine field for the services of the illuminating engineer.

* *Illum. Engineer*, June, 1920, p. 183.

THE REORGANISATION OF NELA RESEARCH LABORATORIES (CLEVELAND, OHIO, U.S.A.).

DR. ERNEST FOX NICHOLS GOES TO NELA PARK.

NELA Research Laboratory was organised in 1908 under the Directorship of Dr. Edward P. Hyde as The Physical Laboratory of the National Electric Lamp Association. The name was changed to Nela Research Laboratory in 1913, when the National Electric Lamp Association became the National Lamp Works of General Electric Company. For some years the Laboratory was devoted exclusively to the development of those sciences on which the art of lighting has its foundation, but in 1914 the functions of the Laboratory were extended by the addition of a small section of Applied Science, which had an immediate practical objective.

The Section of Applied Science is now being largely extended as a separate Laboratory of Applied Science under the immediate direction of Mr. M. Luckiesh, who becomes Director of Applied Science, and a new building is being constructed to house this branch of the work, which will be carried forward with a staff of several physicists, an engineer, an architect, and a designer, together with the necessary technical and clerical assistants.

Dr. Ernest Fox Nichols, formerly President of Dartmouth College, and more recently Professor of Physics at Yale University, has accepted an invitation to assume the immediate direction of the Laboratory of Pure Science, under the title of Director of Pure Science. The work of this Laboratory, which will be continued in the present building, will be somewhat further extended under the new organisation.

The Laboratory of Pure Science and the Laboratory of Applied Science will together constitute the Nela Research Laboratories, and will be co-ordinated under the general direction of Dr. Hyde, who becomes Director of Research.

RELATION OF COST OF LIGHTING TO COST OF LABOUR.

IT is generally understood that the cost of lighting only forms a small proportion, frequently about 1 per cent., of the wages bill, and some confirmatory data on this point has recently been published by the National Mazda Lamp Co. in the U.S.A.

An analysis is made of a plant employing 100 men, and lighted by 100 200-watt tungsten lamps. It is shown that the total operating cost was 1,773 dollars, of which the cost of energy amounted to 1,200 dollars, the maintenance charges to 290 dollars, and interest and depreciation on lighting equipment to 282 dollars.

On the other hand, the wages of 100 men, for 50 weeks, at 25 dollars per week, amounted to 125,000 dollars per annum.

The cost of lighting thus formed only 1·41 per cent. of the wages bill. It is also stated that in this factory increases in lighting equivalent 1 to 5 per cent. of the cost of wages increased production from 8 to 35 per cent.

ILLUMINATING THE INTERIOR OF A GAS MAIN.

WE notice that the *Gas Journal* refers to a suggested method of examining the interior of a gas main by the aid of a small electric bulb, connected to a dry battery, and sealed into the main. When the light is turned on, the interior of the main becomes clearly illuminated, and it is possible to inspect the main at intervals without any escape of gas, and observe when naphthalene is collecting. We have thus one more instance of one method of lighting proving useful in the technicalities of a rival system.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

FOURTEENTH ANNUAL CONVENTION.

THE fourteenth Annual Convention of the Illuminating Engineering Society in the United States is to be held in Cleveland, Ohio, during October 4th—7th in this year. The proceedings will be opened by an address by the President Mr. S. E. Doane, and the usual Report on Progress will be presented. A report is also to be issued by the Committee on Automobile Headlight Specifications, the Committee on Education, and the Committee on Reciprocal Relations with other bodies.

The following series of papers is announced :—

"A Survey of Voltage Conditions in Automobile," by H. H. Magdsick and Howard Karg.

"Modified Views on the Theory of Light," by E. F. Nichols.

"Some Applications of the Photoelectric Cell," by W. E. Story, Jr.

"Knowns and Unknowns of Light Production," by G. M. J. Mackay.

"Optical Principles in Illuminating Engineering," by P. G. Nutting.

"Measurement of Reflection Factors," by G. H. Sharp and W. F. Little.

"A Simple Portable Reflectometer of the Absolute Type," by A. H. Taylor.

"Home and Industrial Lighting Demonstrations, etc.," at Nela Park.

"Central Station Methods for Securing High Lighting Standards in Stores and Homes," by O. R. Hogue, J. J. Kirk and E. D. Tillson.

"Pleasing Proportions of Direct and Diffused Light," by J. R. Cravath.

"The Problem of Brightness," by Bassett Jones.

"Some Out-of-the-Ordinary Applications in Mill Work," by S. G. Hibben.

"An Improved Method for the Illumination of Motion Picture Theatres," by L. A. Jones.

"Recent Applications of Colour in Lighting," by A. D. Curtis and J. L. Stair.

"The High Cost of Poor Lighting," by R. E. Simpson.

"A New Form of Light Meter," by Davis Tuck.

"Further Statistics on Street Accidents," by Ward Harrison.

"Central Station Experience in the Improvement of Factory Lighting," by J. B. Wilson.

"Lighting of Show Factories," by A. L. Powell and J. H. Kurlander.

Finally an address will be delivered by the President-Elect, Gen. G. H. Harries, who will also preside over a joint meeting with the Electrical League of Cleveland and the Cleveland Engineering Society.

THE GAS REGULATION ACT.

IN a paper read before the North British Association, Mr. S. B. Langlands recently discussed the new "Gas Regulation Act," which is of considerable interest to lighting engineers. The Act gives power to the Board of Trade to alter or modify the maximum price of gas, and the use of the word "therm" as a unit of charge occurs for the first time. Mr. Langlands discusses methods of presenting charges and explaining the new basis of rendering accounts to consumers, and he also deals with the important point regarding alterations and adjustments of burners being made by gas companies at their own expense. The question arises whether charges will still be made on the basis of cubic feet, the declared calorific power and minimum permissible pressure being marked on the form; to render accounts in therms would, it is suggested, mean much extra clerical work. The price per therm must be set forth, but presumably consumers would make their own calculation of the value in therms received.

In the discussion, Mr. Samuel Glover remarked that it was satisfactory that the industry had been consulted before the regulations were framed. He believed the Act would allow considerable freedom to the industry, and permit its progressive development.

THE "ARTIFICIAL SKY" METHOD OF STAGE LIGHTING.

READERS will recall that in a paper read before the Illuminating Engineering Society last year Mr. J. B. Fagan spoke with approval of the Fortuny system of stage lighting, involving the use of an "artificial firmament" as the source of light for the stage. According to this method the illumination is entirely indirect, light being reflected off a dome-like diffusing surface, the colour of which can be varied so as to produce delicate transitions in the colour of the reflected light. The method in fact aims at approaching the conditions of natural lighting where light is derived from a more or less cloudy sky.

We notice that this idea has been applied, apparently in a very complete form, in the new Grosse Theatre in Berlin, a description of which has appeared in the *A.E.G. Mitteilungen.* This theatre is the redecorated building of the old Schumann circus, adapted to suit Reinhardt's productions. Reinhardt's idea, it is stated, is to combine the essential structure of the ancient stage (where the present strict division between the stage and the audience did not exist) with the latest appliances of theatrical art. A feature in the Grosse Theatre is the large foreground space in front of the stage, formerly the old circus amphitheatre, which plays a useful part in scenic production. The lighting of the theatre is entirely by concealed methods, the stage and the foreground receiving illumination mainly from a large cupola, the interior of which is lighted by 500-watt lamps in 46 reflectors of a special type, spaced round its rim and concealed from the audience. Importance is attached to the design of these reflectors, which concentrate the rays into a cone, at the apex of which coloured or diffusing glass discs can be inserted. As an additional device to suggest the sky-effect constellations of stars, worked out by small visible glow lamps, are reproduced on the inner surface of the dome.

Similar methods are utilised for the general lighting of the auditorium, passages, foyer, etc. The illumination in these areas appears to be of the order of 1–3 foot-candles.

TESTS OF HALF-WATT LAMPS.

IN view of the meagre data at present available for the life of gas-filled ("half-watt") lamps of the smaller sizes some experience tests recorded in a recent issue of the *Elektrotechnische Zeitschrift* are of interest. The tests were made on a number of 40 watt lamps of the 110 voltage and 120 voltage types. Considerable differences in the performance of different makes of lamps is reported. In one batch of lamps there was a tendency for lamps to explode suddenly in the early part of their life, due apparently to a change in the gaseous contents which became ignited. Of these lamps 30 out of 100 gave way within 1,000 hours, whereas of another batch only one lamp failed. Moreover the shattering of an adjacent lamp seemed to cause others to do the same. Over-running had little effect in causing such failures.

As illustrating the effect of over-running on the life of lamps the following data are of interest:—

Voltage.	Per cent. increase of voltage.	Useful life.		Per cent. diminution in useful life.	
		Make "A."	Make "B."	Make "A."	Make "B."
		Hours.	Hours.		
220	—	1,495	2,080	—	—
235	+ 6·8%	713	1,076	52·3%	49·8%
250	+ 13·6%	480	620	68 %	70·3%
300	+ 36·4%	31	41	98 %	98 %

THE ARTISTIC ASPECTS OF DOMESTIC LIGHTING.

In a lecture entitled "Lighting and the Householder," delivered for the National Electric Light Association at California this summer, Mr. M. Luckiesh remarked that the artistic aspects of domestic lighting rarely received sufficient attention. In general the consumer is approached on the utilitarian basis. Yet as a matter of fact the ordinary householder spends much more in attempts to beautify his surroundings than is necessary from a purely utilitarian point of view; for example, he will make considerable efforts to secure good furniture, beautiful carpets, and tasteful wall papers, but, as a rule, the corresponding possibilities of lighting in a decorative sense are not pointed out to him.

The need for the "Illuminating Engineer" is constantly emphasised. But Mr. Luckiesh contends that there is also a need for what may be termed the "Lighting Artist." The decorator obtains his effects by reflected light. The Lighting Artist would deal with the direct light from the source as his medium.

In bringing this point of view before the consumer, demonstrations are essential. Lighting effects must be shown to the householder, they cannot be adequately described. A show-room should not consist merely in the display of a multitude of fittings. There should be special demonstration rooms, wherein alternative methods of lighting can be demonstrated.

In his lecture, Mr. Luckiesh describes a room of this kind, showing how the greatest possible variety in conditions of illumination can be obtained by combinations in direct and indirect lighting, cove lighting, etc.

Dealing with the lighting of the chief rooms of a house, Mr. Luckiesh remarked that the inverted bowl is quite useful to provide a general subdued lighting in the dining-room, if special illumination is allotted to the table. One interesting special fitting described utilises a form of bowl which appears a warm yellow tint by transmitted light, but carries inside it a lamp with a blue glass bowl, suitable for producing "artificial daylight." In this way the colours of objects on the table are correctly revealed, but a pleasing contrast is made by the warm coloured light penetrating the sides of the bowl, and illuminating the outskirts of the room.

Novel effects in coloured lights may be obtained by means of lamps concealed in wall boxes, or in a cove running round the room. If two circuits provided with blue and yellow orange lamps respectively are installed, either of these tints or a combination of them can be used, as a variant to the ordinary lighting.

The idea is that the householder should be taught to appreciate the possibilities of lighting as a decorative element and that there should be considerable potentialities for variation, while the main principle determining the lighting of the chief rooms in a house from the practical standpoint should be complied with, there is scope for ingenuity in devising striking effects—especially for use on festive occasions when there is company and it is desired to make the rooms interesting and attractive.

A SELF-CLEANING LIGHTING FIXTURE.

In a recent issue of the *Electrical World* an account was given of a Self-Cleaning Lighting Fixture, introduced by a firm in Chicago, under the name of the "Clean-Pull" unit.

The fixture consists of a reflector, a pull switch, a cord and a cleaning device consisting of two wiping blades. Every time the cord is pulled to operate the switch it simultaneously brings the two wiping blades into action. Each blade makes a complete revolution, one against the reflecting surface of the reflector, and the other against the lamp bulb. In this way the dirt is swept off both lamp and reflector. The fixture is made to take 300-watt to 500-watt lamps, and is sent out completely wired and assembled so that any maintenance man may erect the unit on existing outlets.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

PROFESSOR John Bretland Farmer, D.Sc., M.A., F.R.S., Imperial College of Science and Technology, has been appointed by an Order of Council dated the 28th day of August, 1920, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

We understand that H.M. Stationery Office have published for the Department of Scientific and Industrial Research a Report entitled "Coal Fire," which describes the work of Dr. Margaret Fishenden in connection with domestic heating. Copies (post free 4s. 3d.) can be obtained from H.M. Stationery Office, "Imperial House," Kingsway, W.C.2.

Another publication of interest is the translation of Von Rohr's "Theorie der Optischen Instrumente," undertaken by Mr. R. Kanthack. The translation of this treatise is expected to prove most useful to students and scientists. Amongst others the following subjects are dealt with: The Fundamental Principles of Geometrical Optics; The Computation of Rays through a system of Refraction Surfaces; Abbe's Geometrical Theory of the Formation of Optical Images; The Formation of Optical Images; The Theory of Spherical Aberration; The Theory of Chromatic Aberration; Computation of Optical Systems in accordance with the theory of Aberration; Prisms and Systems of Prisms; The Limitation of Rays in Optical Systems (Theory of Stops); Intensity of Rays transmitted through Optical Systems (Photometry of Optical Instruments).

Copies (£2 5s. net) can be obtained from H.M. Stationery Office, "Imperial House," Kingsway, W.C.2.

FORTHCOMING ADVERTISING EXHIBITION.

AN interesting event this autumn will be the International Advertising Exhibition to be held at the White City, London, from November 29th to December 4th.

We understand that the buildings will have an area of 200,000 square feet, and that the space will be occupied by interesting and novel demonstrations of the value of modern advertisements as an instrument of salesmanship.

It is stated that the Government, particularly the Board of Trade, is interested in this endeavour to aid the commerce of the Empire, and likewise the Trades Commissioners of our Colonies.

Particulars of the Exhibition can be obtained on application to the Administrator, Mr. S. G. Haughton, 167, Strand, London, W.C.

BRITISH INDUSTRIAL "SAFETY-FIRST" ASSOCIATION.

AT the Machine Tool Trades Exhibition to be held at Olympia in September next a great Convention will be held under the joint auspices of the Home Office and the British Industrial "Safety-First" Association. There will be two sections, at which papers of absorbing interest will be discussed. We understand that special attention will be devoted to the part played by industrial illumination of the prevention of accidents. Engagements permitting, the Home Secretary will preside at the morning session and Lord Leverhulme in the afternoon.

Invitations to the Convention are being extended to the management and workers of the principal industries throughout the country, to employers' federations, employees' organisations, National Union of Manufacturers; also to representatives of Government Departments and numerous other personages prominent in commercial and industrial circles.

The arrangements for the Conference are in the hands of Mr. Gerald Bellhouse, C.B.E., the Deputy Chief Inspector of Factories and Workshops, and Mr. H. E. Blain, C.B.E., the well-known Operating Manager of the Underground Railway and London General Omnibus Group.

GEORGE MONTEFIORE FOUNDATION.

Triennial Prize.

WE have received from the Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore (Liège) particulars of the prize to be awarded under the George Montefiore Foundation for the year 1921. The prize consists of the accumulated interest on a capital of 150,000 francs invested in Belgian 3% Rentes, and is awarded every three years for the best original work presented on scientific advance and progress in the technical applications of electricity. Competitors may send in treatises up to April 30th, 1921, and all particulars can be obtained from the Secretary of the George Montefiore Foundation, Rue Saint Gilles, 31, Liège, Belgium.

TOPICAL AND INDUSTRIAL SECTION.

[The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

GLASS-TOP METAL REFLECTORS.

Some time ago we referred to a novelty recently introduced in the United States, namely, the use of metal reflectors having a translucent glass top. The idea of the device is that this glass allows enough light to be transmitted upwards to illuminate the ceiling and upper parts of the room to a moderate extent, and in this way removes the tendency towards severe contrast and glare which may occur when only metal reflectors, at a relatively low level, are used. At the same time the shadows are softened.

By the courtesy of the makers of these reflectors (the Ivanhoe-Regent Works of the General Electric Co., of Cleveland, U.S.A.), we reproduce on the opposite page two illustrations explaining the principle. The upper view shows, in an extreme form, the appearance of lighted metal reflectors seen against a completely dark ceiling; while the lower view is intended to illustrate the effect produced with glass-top metal reflectors

In practice it frequently happens that the upper parts of rooms illuminated entirely by metal reflectors are unduly dark, though when the walls and floor are light in colour a considerable amount of light is reflected upwards and softens the contrast. The idea of avoiding such extreme contrasts by the use of combination glass and metal fittings is interesting. Such a device is essentially a compromise between metal and prismatic or diffusing glass reflectors, and appears to achieve, in a compact way, what is done when one subdivides the lighting of an interior, making special arrangements to illuminate the upper part of the room and using metal reflectors for the direct light on the work.

SIEMENS DRY CELLS AND BATTERIES.

A recent catalogue (No. 537) issued by Messrs. Siemens Brothers and Co., Ltd., contains particulars of a great variety of dry cells and batteries, which the Company has manufactured in its Woolwich Works for nearly 30 years. The number of types and sizes made at Woolwich now exceeds 600, including dry cells of round, square and oblong shape, cells specially designed for telephones and bells, dry batteries for ignition or for internal combustion engines, batteries for pocket flash lamps, torches, etc.

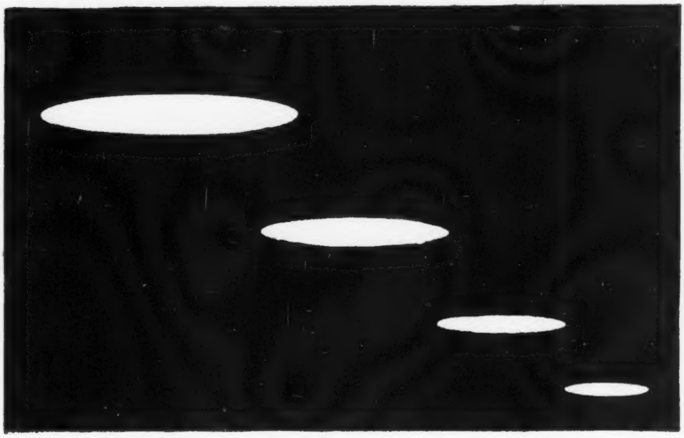
The catalogue also contains an illustrated description of the Siemens "Inert" cells, which, it is stated, may be stored for an indefinite time in any climate without undergoing deterioration. The cell is rendered active by the addition of water, which is absorbed by its ingredients so that it subsequently behaves like a dry cell of the best type.

FITTINGS FOR "HALF-WATT" LAMPS.

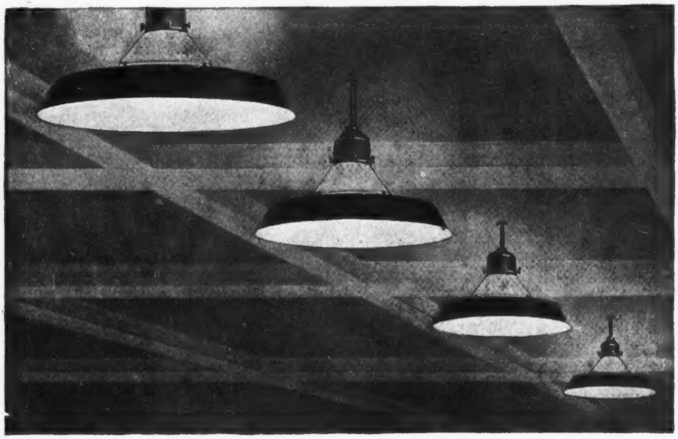
A booklet issued by the Engineering and Lighting Equipment Co., Ltd., who have taken over the business of "Engineering and Arc Lamps, Ltd.," shows an interesting variety of fittings for gas-filled lamps, one type of special interest being the "Bradford" colour-matching lantern which contains glass of special colour desired to convert the light from an ordinary gas-filled lamp into a close resemblance to daylight. The booklet also illustrates the application of the "Anti-Break" anti-vibration discs, which consist of concentric rings of springy phosphor-bronze and gauze, whereby shocks and vibrations are absorbed and prevented from affecting the filament.

G.E.C. TURBO-PLANT.

We have received from the General Electric Co., Ltd., two catalogues, dealing respectively with Turbo-Plant (Bulletin No. 13), and with Fraser and Chalmers' Steam Turbines (Bulletin No. 13A).



Illustrating the effect of metal reflectors which are apt to leave the top of the room in comparative darkness unless supplementary general illumination is provided.



With glass-top metal reflectors the ceiling receives just enough transmitted light to eliminate severe contrast with the brightly-lighted reflector below.

Two illustrations showing the effect of Metal Glass-Top Reflectors in diminishing the Contrast between the lighted surface of the reflector and the upper part of the room.

ELECTRIC LAMPS IN JAPAN.

According to the *Electrical Review*, the electric lamp trade in Japan is a very prosperous one. The consumption of electric light in 1917, as compared with 1912, shows an increase of 250 per cent. Accordingly, the demand for electric lamps has increased steadily, and for this year is estimated at 23,000,000 bulbs. The value of bulbs exported rose from 160,284 yen in 1912 to 2,847,187 yen in 1917, when approximately 8,000,000 bulbs were exported. The total for this year is estimated at 14,000,000. Between 80 and 90 per cent. of all electric lamps manufactured in Japan are made by the Tokio Electric Works, which is a branch of the General Electric Co.

IMPROVEMENTS IN STREET LIGHTING IN LONDON.

While the general tendency in electric street lighting since the cessation of hostilities has been in the direction of substituting gas-filled incandescent lamps for arc lamps, there are still too many cases in which such lamps are merely installed in the old fittings, without any scientific means of distributing the light. Oxford Street, with its series of lamps in Holophane prismatic glass lanterns, is a familiar exception to this tendency, and more recently a number of fittings of this type have been installed in the Strand and in the upper section of Whitehall approaching Trafalgar Square. In both cases the contrast with the conditions prevailing during the war is very marked.

PUBLIC LIGHTING IN NOTTINGHAM.

We notice that, according to the *Gas Journal*, the Gas Committee of Nottingham have at last seen their way to a reversion to the pre-war arrangements for public lighting. It certainly seems singular that this step should have been so long deferred, and it is satisfactory to notice that a comprehensive series of improvements, including the discarding of various obsolete devices, for street lighting is now contemplated.

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION.

We have received from the British Electrical Development Association a series of pamphlets referring to the applications of electricity for domestic uses. An illustrated booklet, entitled "Household Helps," deals with electric lighting in the home, pointing out the advantages of proper methods of illumination and the use of modern systems of wiring, etc. We are glad to note that special importance is attached to the elimination of glare from unscreened filaments.

THE UNHARMED MAZDA.

An incident, brought to our notice by the British Thomson-Houston Co., Ltd., illustrates the shocks which drawn-wire filaments will sometimes withstand.

A tramcar belonging to the Ayr Corporation had the misfortune to collide recently with a motor car. The motor was smashed beyond recognition, while the tramcar was badly damaged, the front being twisted and bent. In the middle of the dashboard (which sustained the full force of the collision) there was a headlight equipped with a Mazda traction type lamp. Although the glass front of the headlight was broken and the bolts securing the metal framework sheered off, the Mazda lamp continued to burn after the accident. It is surprising that a thing of glass and wire should survive such a collision and remain unharmed in the midst of twisted steel and splintered wood.

ACETYLENE TORCHES FOR GAS LAMPS.

Another instance of one system of lighting coming to the assistance of another is afforded by the special acetylene torches supplied by Messrs. Parkinson and W. & B. Cowan, Ltd., for use with their street lamps using inverted burners. The lanterns are adapted to the use of automatic controllers or may be lighted by any ordinary form of torch. The acetylene torch, however, appears to be a compact and useful device allowing a stiff flame to impinge sideways on the gas without the torch itself being brought unduly near the mantle. The torch contains sufficient carbide and water to serve for a long round before recharging is necessary.

INDEX, August, 1920.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Engineering Enquiry. By Tomey Thompson. (*J. W. Arrowsmith, Ltd., Bristol, and Simpkin, Marshall, Hamilton, Kent and Co., Ltd., London. 7s. 6d. net. pp.* 365.)

IN an introductory note the Author of this work recalls the statement of a director of a prominent Engineering Manufacturing Company that he rarely received an inquiry complete, *i.e.*, without delay being caused by correspondence and interviews to elicit information necessary before an intelligent tender could be submitted.

This difficulty the Author seeks to rectify. He provides a summary of the essential facts with which a manufacturing firm desires to know when an inquiry is received. The subjects of inquiry (motors, pumps, instruments, etc.) are arranged in alphabetical order. Besides giving data on the lines indicated, the Author in some cases gives a brief analysis of the respective merits and drawbacks of alternative arrangements. The book should be most valuable to purchasing and selling engineers, agents, managers and others concerned with orders for engineering machinery.

Debentures, the Purposes they Serve and How they are Issued. By Herbert W. Jordan. (*Jordan and Sons, Ltd. Ninth Edition. London,* 1920. 1*s.* 6*d. net. pp.* 65.)

THE title of this book, now in the ninth edition, explains its contents. It is divided into two parts, the first explaining the nature and objects of debentures, the second the method of issue. Readers are warned against various misuses of debentures, and some curiosities, such as debentures charged on "gate money" and even on golf balls, are mentioned! The book will doubtless be useful to many embarking on financial undertakings.

Who's Who in Engineering. Edited by John Ed. Sears, C.B.E., M.A. (1920–1921.) (*Compendium Publishing Co., London. pp.* 426.)

THE edition of "Who's Who in Engineering" for 1920–21 contains the usual list of leading engineers, arranged alphabetically, and a classified list of experts. Particulars are given of Engineering Institutions and Societies, Centres of Technical Engineering Training, Trading, and Research Associations, Associations of Employers and Employees, Engineering Journals, etc. In the nature of things such a publication must require constant revision, and we note that it is hoped in future to make the classified list of engineers more complete. Meantime the Editor invites particulars from leading engineers, secretaries of institutions, etc., and in a notice at the end of the work an indication is given of the form in which such information should be presented.

The Electricity (Supply Act), 1919. *By W. S. Kennedy, LL.B.* (*The Electrical Review, Ltd., London,* 1920. 3*s.* 6*d. net. pp.* 96.)

THE book consists of a complete summary of the 1919 Electricity Supply Act, each section being analysed and commented upon in turn. On the whole, the Author seems to view the Act favourably, regarding the creation of the Commission as a step in the right direction, and in so far as it helps to remove impediments and effect reconciliation between conflicting interests its effect should be good. But where it goes beyond this the result is considered doubtful, and the Author issues a warning against the impression that cheap electricity can be secured by Act of Parliament. It is rather to the energy and inventive genius of the engineer that we must look for the solution of this problem.

The Journal of the Society of Glass Technology. (*August,* 1920.)

THIS number contains the account of the proceedings at the Third Annual Meeting, from which we are glad to note that the Society is making steady progress. Seven papers are presented, including some notes on the discolouration produced by lead, antimony and arsenic in lamp-worked glass tubing, by F. W. Hodgkin and W. E. S. Turner, and the discussion of Dr. Peddle's papers on the Development of Optical Glass during the War. The volume is concluded by the usual abstracts and reviews of articles on glass technology. A section on Illumination and Illuminating Ware is now included.

The Theory and Practice of Lubrication: The Germ Process. By H. M. Wells and J. E. Southcombe, M.Sc. (*Reprint of Paper read before the Society of Chemical Industry.*)

IN this paper the Authors review the theory of lubrication and seek to explain the differences found in the qualities of various types of oil, which are illustrated by the results of tests on marine steam engine bearings, steam cylinders and turbines, etc. The expression "germ process" is used to describe oil made by using a small amount of fatty acids with mineral oils. For many purposes the addition of fatty oils to mineral oils is considered unnecessary.

Good Lighting (No. 5). Edited by Mr. D. H. Ogley.

CONTAINS some hints on industrial lighting, and illustrates some of the most recent productions of the Wardle Engineering Co., Ltd., for use with gas-filled lamps. A note on heat losses in vacuum and gas-filled lamps is included, in which the actions taking place in the gas-filled lamp are explained. We notice that the booklet contains a quotation from THE ILLUMINATING ENGINEER on some illumination tests in Australia.

The Practical Electrician's Pocket Book.

WE understand that "The Practical Electrician's Pocket Book (issued by Messrs. S. Rentell and Co., Ltd.), which has been previously reviewed in these columns, has now been included in the list of books which are officially recommended by the City and Guilds of London Institute.

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The
ELECTRICITY · ACETYLENE · OIL · GAS
ILLUMINATING ENGINEER
Edited by
LEON GASTER

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EDITORIAL.

Lighting in Relation to Health and Safety.

Several recent events have served to emphasise the importance of good lighting in the interests of health and safety. Amongst these great interest attaches to the first conference of the British Industrial Safety First Association, held at Olympia on September 22nd. The Home Secretary was to preside during the morning session, and Lord Leverhulme in the afternoon—an arrangement which aptly illustrated the cordial support which the movement now receives, both in official quarters and in the field of industry. The proceedings were opened by an introductory address by Mr. G. Bellhouse, C.B.E. (H.M. Deputy Chief Inspector of Factories), and a number of other officials, including Sir Arthur Whitelegge, K.C.B., and Mr. Graves (H.M. Chief Inspector of Factories), were present. Frequent references were made to the part played by illumination in ensuring the safety of operators in factories. Thus, Dr. John Bridge, in referring to first aid in factories, remarked that lighting and temperature had a great influence on the accident rate—lighting, particularly, being a matter that did not yet receive the attention it deserved. Mr. Atkinson, Welfare

Superintendent at Port Sunlight, referred to the use of luminous signs above railway tracks at frequent intervals. In addition the writer contributed a paper on "Lighting as an Aid to Safety," in which he presented statistics illustrating the connection between lighting and accidents, and pointed out the desirability of introducing a general requirement of adequate lighting in the new Factory Acts. The use of luminous signs and devices should receive special attention as an element in safety measures. Of what use is the display of a cautionary placard, unless it can be clearly seen both by natural and artificial light? Such notices should be so lighted as to "stand out" and be easily read by the workers using the machines to which the notice applies.

Several of the speakers in the discussion at Olympia remarked that first aid and safety measures should not be interpreted too narrowly. They should be directed towards safeguarding the health of workers, as well as their protection against accidents. Both these aims form an important part of industrial hygiene.

Another important step is the proposed resumption of meetings of the Departmental (Home Office) Committee on Factory Lighting, which were temporarily suspended during the war following the issue of the first Interim Report in 1915. The intervening period has only served to bring about a more general recognition of the importance of good industrial lighting in the national interests and the Committee has before it many useful lines of future work. We have often pointed out that this question of industrial lighting is one that should receive international treatment, and that some machinery should be instituted to pool the information obtained in different countries and promote common action. It was therefore very gratifying to learn from Professor Carozzi, who is associated with the Section of Industrial Hygiene of the International Labour Office established by the League of Nations, that lighting is one of the subjects to which it is proposed to devote special attention.

We are glad to observe that a Committee has now been appointed under the Ministry of Health (*see* p. 248) to inquire into the causation of blindness and defective vision, and we have reason to believe that it will include in the scope of its inquiry the effects of inadequate lighting and excessive glare—doubtless contributory factors in the causation of blindness and defective vision.

One question recently discussed before the Illuminating Engineering Society suggests itself as a very appropriate one to receive attention from this Committee—namely, the relation between inadequate illumination and miners' eyesight. It is generally agreed that inadequate lighting is one of the chief causes of miners' nystagmus, and the Committee seems to be in a good position to initiate researches such as would enable us to trace the conditions of lighting responsible and prescribe a remedy.

Again, there is a widespread impression that the deterioration in the eyes of children during their school life is at least partly due to inadequate lighting. Finally, the effect upon eyesight of the glare from the powerful lamps used in cinema studios has been the subject of recent comment. These questions also deserve attention from the Ministry of Health Committee.

Illumination and Output in the Silk-Weaving Industry.

When the formation of the Industrial Fatigue Research Board was announced we pointed out the prospect of valuable work before this Committee, and expressed the hope that the effect of inadequate lighting in causing fatigue would be included in its scheme of operations.

We have now before us an interesting bulletin issued by the Board on "Output in Silk Weaving during the Winter Months."* The report deals with two different mills, one devoted to light goods, the other to fancy materials. Measurements of output during successive weeks were regarded as one of the best available indications of the extent of industrial fatigue.

The interesting point about these researches is the relation established between output and the extent to which artificial light was used. In one mill centrally controlled lighting was used, and it was possible to record the exact number of hours during which artificial light was necessary. The working day was divided into eight successive periods, and it was found that in general the first and last periods furnished the smallest output. The relative diminution in these periods, however, is shown to be closely associated with the use of artificial light. As the days became longer and the natural light brighter the output improved. By comparison between weeks in which artificial lighting was necessary, and corresponding weeks when daylight was used throughout, it is deduced that the loss of output arising from the use of artificial light amounted to 10%. In the other mill local lights under the control of individual workers were necessarily used, and accordingly an exact record of the hours of artificial light could not be kept. Nevertheless, the records, properly interpreted, confirm the influence of artificial light on production.

The general conclusion is that as we proceed from the dark winter months to the spring, when more daylight is available, the output steadily rises. This result supplements the conclusion already recorded in the Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops that accidents are most frequent in the dark winter months, and least in the summer. It appears therefore that the methods of artificial lighting used in factories are frequently less safe and less efficient than daylight. It need not be assumed that this is *necessarily* so. What is now needed is to trace the conditions of artificial lighting responsible for the inferior results. In some cases doubtless the amount of light is inadequate, in others the distribution of light, the direction from which it is received, the nature of the shadows and the presence of glare may be important factors. We should like to see this investigation extended to various methods of artificial lighting, thus revealing the conditions of illumination to be avoided. It may be found possible to equal, and even exceed, results achieved by daylight, which, with all its advantages, has also drawbacks, notably as regards lack of uniformity of illumination over the working area, and great variation with the time of day and period of the year. The Committee is to be congratulated on the useful work already done, and the fact that its Chairman (Professor C. S. Sherrington) and its Secretary (Mr. D. R. Wilson) are also members of the Departmental Committee on Lighting in Factories and Workshops should ensure that the effect of lighting conditions in relation to fatigue will receive due attention.

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* Bulletin No. 9 (Textile Series No. 3), issued by the Industrial Fatigue Research Board, and obtainable from H.M. Stationery Office (Imperial House, Kingsway, London, W.C.).

B

Scientific and Industrial Research.

The Annual Report of the Department for Scientific and Industrial Research for the past year contains evidence of a great extension of work. Apart from the National Physical Laboratory and the various Research Boards there are eighteen industrial research associations representing various industries, and others still in course of formation. Aid has been given to a number of scientific researches carried out by other bodies, and grants have been made to 159 individual researchers—a notable advance over the number for the previous year. A few committees formed under the Department have been dissolved, but it may safely be assumed that in such cases their activities have merely been merged in some other inquiry.

Space prevents us dealing here with the nature of these varied and comprehensive researches, of which some account is given elsewhere in this issue (pp. 255–256). We should, however, like to refer to one or two matters of principle discussed in the Report. It appears that grants to private workers are intended to apply to purely scientific work, whereas work done by the recognised industrial associations may be expected to have a direct practical bearing. The question arises as to the position of inventions made by persons carrying on state-aided researches. Twelve patents have been taken out by the Trust in conjunction with inventors. We have always contended that researchers who are able to develop an invention of commercial importance should be entitled to some share of the proceeds of their work. The remuneration they receive, either in the form of salary as an accredited research worker to some association, or as a grant for their personal work, is admittedly not such as to alone encourage gifted young men to devote their lives to research. We are therefore glad to observe that the problem of dealing with inventions made by workers aided by public funds "so as to give a fair reward to the inventor and encourage further effort" is being dealt with by a Departmental Committee.

Another point is the position of scientific societies in regard to the publication of their transactions. As is well known the costs of printing and paper have advanced enormously during the war, and in many cases it has been found necessary to reduce the volume of publications. The increased costs of publication thus act as a deterrent to the dissemination of scientific knowledge, a condition which is obviously unfortunate at the present moment. In certain cases important scientific documents have been issued through the Stationery Office, but this is rightly regarded as no substitute for the increased support needed by scientific societies to make their results known. The question of state-aid is regarded as a difficult one, but it is suggested that common action should be taken by scientific societies in presenting a definite statement in favour of temporary assistance during the present period of unsettled prices. We understand that a movement in this direction has been initiated. Scientific societies also suffer through the increased cost of postage, and we have previously urged that scientific publications should enjoy at least the same postal rates as those granted to daily and weekly newspapers.

LEON GASTER.

OUTPUT BY NATURAL AND ARTIFICIAL LIGHT IN THE SILK INDUSTRY.

SOME interesting data on the above subject are given in a bulletin recently issued by the Industrial Fatigue Research Board.* An investigation into the silk industry was originally suggested by the Home Office on the grounds (*a*) that research by the Board might be of assistance in regard to the changes in hours of employment at the time under consideration, (*b*) that the special fineness of many of the processes gives much of the work an individual character not possessed in the same degree by other textile industries. The report is based almost entirely on variations in output which, in the absence of any known physiological or psychological test, is at present the only practical index of fatigue. Such an index, however, is only applicable to processes in which fatigue can show itself in reduced output, *i.e.*, those in which production depends to an appreciable extent on human effort. Many processes in silk manufacture are nearly automatic, and output is then only slightly affected by the human factor. Such processes are naturally unsuitable for correlating output with fatigue. Weaving, however, stands in a different category. Here the output depends to a much greater degree on human effort. Accordingly the enquiry was conducted in two silk-weaving factories, one on plain, the other on fancy silks. A specially interesting point is the reduced output, as compared with that obtained by daylight, observed during hours when artificial lighting was used.

In commenting on the difficulties attending such an enquiry it is remarked that the climatic conditions have a marked effect on the working capacity of the individual; there is a great difference between the condition of mind on a bright spring day, a hot summer day in July, or a foggy day in November. Atmospheric conditions also affect the material being manufactured. The lighting of a factory, again, whether by daylight or by artificial light, also greatly affects the rate of production. The effect here is twofold—psychological in that certain lighting systems are depressing and others stimulating, and physical in that threads of yarn are more easily seen in some lights than others.

The two investigations I. and II. were carried out in two mills of widely varying character, both as regards their structure and the nature of the product.

INVESTIGATION I.

The first investigation was made in a weaving mill in Essex. This was a modern lofty shed with roof lights facing north. The looms were widely spaced, there was little obstruction, and the appearance of the shed was, as weaving sheds go, distinctly cheerful. Each loom was lighted artificially by two 30-watt lamps—one, suspended about one foot from the cloth, fell at the end of an arm hinged to a bracket at the front centre of the loom frame, the other suspended 2½-3 ft. above the porry of the warp. The work was of a simple character and all materials used were of a light colour.

One of the first steps was to determine a method of determining the efficiency of work, on which output depends. Eventually the two following criteria were adopted :—

$$(1) \quad \frac{\text{Number of picks in woven cloth} \times 100}{\text{Number of picks in a non-stop loom would have made.}}$$

$$(2) \quad \frac{\text{Time taken by non-stop loom to weave the cloth in question} \times 100}{\text{Actual time taken.}}$$

The artificial lighting was centrally controlled, and it was accordingly possible to record the exact period during which artificial light was used.

* No. 9. *A Study of Output in Silk Weaving during the Winter Months.* (Textile Series No. 3.) Issued by H.M. Stationery Office, Imperial House, Kingsway, London, W.C.

The working day was divided into eight divisions, four occurring before the luncheon hour and four after, and the output in each period noted. As this was continued for a considerable time, it was possible to trace also the characteristics of different days in the week, and to compare results in successive weeks of work. Two methods of dealing with the work, described as methods A and B, were adopted.

In method A an addition was made of all the picks produced in a period; this number was divided by the number of looms actually producing cloth, and an allowance for time was made so as to render the results representative of one hour's work. No account is here taken of the comparative difficulty of working with different kinds of cloth, and to meet this objection method B was adopted, in which the cloths were divided into five groups, and in computing output due account was taken of the relative difficulty of working in each case.

The figures obtained for the first three weeks are not recorded. Tabular data for the subsequent first recorded week of working were very consistent, methods A and B leading to substantially the same results. Period 1 (7.30-8.30) shows, as is usual in factories, comparatively inefficient results. Some time is needed for operators to settle to work, and artificial lighting is used.

During the second period output rises, but probably normal conditions have still not yet been attained. Period 3 should be the best morning period. In Period 4 there is a slight diminution in results, due partly to fatigue and probably to unconscious slackening of effort before the dinner hour. In the afternoon there is a similar cycle, Period 5 is, however, better than Period 1, owing to the fact that artificial light is not used. Period 6 is the most productive period in the afternoon, Period 7 *should be* a highly productive period but for the fact that artificial light is used for two-thirds of the time. Period 8, the last period of the day, is the least productive, causes including the use of artificial light, slackening of effort, and the existence of a definite state of fatigue.

In the accompanying table the average results for a number of complete working weeks are set out.

TABLE I.

DISTRIBUTION OF OUTPUT FOR ALL LOOMS DURING VARIOUS PERIODS OF THE DAY.

Weeks.		Period of Day.							
		1	2	3	4	5	6	7	8
		7.30 to 8.30	8.30 to 9.45	9.45 to 11	11 to 12	1 to 2	2 to 3.15	3.15 to 4.5	4.15 to 5.15
"A"	4—6	43·0	48·2	51·5	49·2	49·0	52·5	48·1	41·5
	7—9	47·7	51·7	54·0	52·4	51·6	53·4	53·4	49·9
	10—12	50·4	54·3	56·1	55·2	54·2	55·3	55·6	49·8
"B"	4—6	41·1	47·6	50·9	49·2	48·4	52·0	46·9	40·8
	7—9	44·7	49·7	51·9	50·3	49·3	51·0	50·9	44·4
	10—12	46·0	50·4	51·9	50·9	50·0	51·4	51·6	45·8

Weeks.	Use of Artificial Light during Three Periods.			
	A.M.		P.M.	
	Hours.	Minutes.	Hours.	Minutes.
4—6..	1	9	1	25
7—9..	1	1	—	47
10—12..	nil		nil	

The table shows clearly how, during the four morning periods, the output rises sharply after the first period but shows a slight set-back in the fourth period before the dinner hour. In the afternoon for the first three periods there is again a rise, but less pronounced, while for the final period of the day there is a very marked drop. This seems to show clearly the influence of the use of artificial lighting during the first and final periods of the day. What is particularly to be noted, however, is that the low values in the first and last periods of the day become better during weeks 7–9, when little artificial light was used, and very much better for weeks 10–12, when no artificial light was used.

From these figures it is possible to calculate directly the influence of artificial light in diminishing output. As method B was regarded as the best test of output it was considered better to work with these figures (though method A would give somewhat similar results). The differences between the outputs 41·1 and 46·0 in the first morning period and between 40·8 and 45·8 in the last afternoon period would appear to be due entirely to artificial light. We therefore get—

$$\frac{46 - 41{\cdot}1}{46} \times 100 = 11 \text{ per cent.}$$

and

$$\frac{45{\cdot}8 - 40{\cdot}8}{45{\cdot}8} = 11 \text{ per cent.}$$

as the percentage loss of production due to working by artificial light in the two cases. The absolute agreement between the calculations is probably accidental, but it is certain that there was a considerable fall in the rate of production during the periods of artificial light of the order of 10 per cent.

The loss did not appear to be due to insufficient electric light. Illumination at the cloth fell varied from 3–35 foot-candles, and on the porry from 5 to 3 foot candles. It is worthy of note that the effect of working under artificial light appears to persist for some time afterwards when daylight is resumed. Possibly the slower pace at which work is carried out by artificial light is unconsciously continued in natural light and acceleration only takes place gradually.

Investigation II.

The second investigation of the inquiry was carried out in an old silk mill in Cheshire, where work of an intricate nature on coloured silks was done. The natural lighting was from windows in the walls. The central looms fared badly as regards the amount of natural light received, and a high building opposite one corner interfered greatly with access of light. Generally the natural lighting was uneven. Each loom was provided with two 30-watt lamps, and in view of the fineness of the work, the dark texture of material and the uneven natural lighting, the control of these lamps was left in the hands of operators. In this case the working day was divided into six periods of 1½ hours each, three in the morning and three in the afternoon.

Typical results are given in Table II.

It will at once be observed that the course of events here is somewhat different from that recorded in Table I. For example, in the first row of figures there is no marked reduction of output in the first period, while the reduction

TABLE II.

Distribution of Output (90-minute Averages) during Three Consecutive Periods.

Weeks.	Period.					
	Morning.			Afternoon.		
	1	2	3	4	5	6
1— 5 (Nov. 17—Dec. 20)	35·0	35·4	35·7	36·3	35·5	34·1
7—11 (Dec. 29—Jan. 31)	35·9	37·8	37·1	37·4	37·2	34·7
12—15 (Feb. 2—Feb. 28)	36·4	39·9	39·7	38·7	39·9	38·2

during the last period of the day is much less than was recorded in the first investigation. As we proceed to the later weeks the figures as a whole tend to rise, the increase occurring *first* in the middle periods but ultimately applying to the whole day, so that once again the unfavourable first and last periods are brought into nearer agreement with the others.

This is explained as follows: Because of the system of individual control of the lights it was not possible, as in Investigation I., to record the period of the day during which artificial light was used. But observations during November and December showed that artificial light was used to a considerable extent in these months, even during the middle periods of the day. From December onwards the days become longer, the brightness of the daylight increased, and the necessity for artificial light disappeared first in the mid-periods of the day. Consequently the rise of output in these periods was greater than in the end periods. The reason for the big increase in the output in the last period of the day for February is probably to be found in the bright and stimulating weather which was experienced in that month. The arrangement of the figures shows clearly that production was lost when artificial lighting became necessary.

The conclusions of the whole investigation, in regard to artificial lighting, may be summarised as follows:—

(1) There is a gradual increase in the output of silk weavers during the period December to March, occasioned principally by the reduction in the length of the time of day during which artificial lighting is necessary, and to a smaller degree by the disappearance of the depressing influences of the winter months.

(2) Under artificial illumination production falls, even if electric light of sufficient intensity is provided. The magnitude of this fall is of the order of 10 per cent. of the daylight value of the rate of output. Every unnecessary hour under artificial light means a direct loss of production and makes the task of the worker more difficult than it need be.

THE CAUSATION OF BLINDNESS.

We are informed that a Committee has been appointed by the Ministry of Health to investigate and report upon the cause of blindness as well as of defective sight adequate to impair economic efficiency, and to suggest measures for prevention. The following have been asked to serve: The Rt. Hon. G. H. Roberts, M.P. (Chairman), Mr. Stephen Walsh, M.P., Mr. N. Bishop Harman, Mr. J. B. Lawford, Mr. G. F. Mowatt, Mrs. Wilton Phipps, Mr. J. Herbert Parsons (representing the Royal College of Surgeons), Dr. James Taylor (representing the Royal College of Physicians), Mr. J. C. Bridge (representing the Home Office), Dr. A. Eichholz (representing the Board of Education), Mr. J. S. Nicholson (representing the Ministry of Labour), Mr. W. M. Stone (representing the Scottish Office), Mr. E. D. Macgregor (representing the Ministry of Health). A representative of the Medical Research Council will be appointed later. Joint Secretaries are as follows: Dr. R. A. Farrar and Mr. P. N. R. Butcher, Ministry of Health, Whitehall, S.W.1.

Obituary.

DR. W. P. NUËL.

We regret to record the death of Dr. W. P. Nuël, who passed away at Liége on August 21st. Dr. Nuël held the professorship of ophthalmology and physiology of the senses at Louvaine University, and was one of the founders of the Belgian Ophthalmological Society. He was keenly interested in the hygienic aspects of lighting and took part in various international congresses where this subject was discussed. As a corresponding member of the Illuminating Engineering Society, Dr. Nuël, only a few months ago, afforded valuable help to the Society in obtaining particulars of researches on the relation between inadequate lighting and nystagmus in the mines of Belgium.

THE ANNUAL REPORT OF H.M. CHIEF INSPECTOR OF FACTORIES (1919).

THE Annual Report of the Chief Inspector of Factories for the past year contains much interesting information and is arranged in a somewhat different form from that customary a few years ago. After the usual introductory statement of the Chief Inspector, there follow a series of twelve sections dealing respectively with Industrial Developments and State of Trade, Safety, Dangerous Trades, Use of Electricity in Factories, Sanitation, Industrial Diseases, Twister's Disability in the Cotton Trade, Welfare in Factories and Workshops, Ambulance and First Aid, Employment and Hours of Work, Night Employment of Young Persons, The Silk Industry and Joint Industrial Councils and Trade Boards.

The need for safety appliances and "safety first" methods is strongly emphasised throughout the report, and it is encouraging to see that, on the whole, employers and workers alike seem to be taking a keen interest in such measures, while in many factories safety committees have been formed.

Fatal accidents increased from 1,287 in 1914 to 1,385 in 1919, while non-fatal accidents fell off from 158,585 to 124,632. In view of the great trade activity during the year the latter result is unexpected, and it appears probable that while fatal accidents have been fully reported there has been laxity in reporting non-fatal ones. A feature of the year's work has been the issue of a number of pamphlets dealing with canteens, welfare work, safety methods, etc. Reference is made to the International Labour Conference at Washington which was attended by Mr. Bellhouse, Dr. Legge and Miss Constance Smith, as advisers to the British Government delegates. Sir Malcolm Robinson relinquished his appointment as Chief Inspector at the end of 1919, his place being taken by Mr. R. E. Graves.

Of special interest to readers of this journal is the chapter on Sanitation by Mr. C. F. Wright and Miss Slocock. It is remarked that there is evidence of progress, both in lighting by gas and electricity. Ceiling (indirect) lighting appears to be coming into more general use. Arc lamps are being replaced by gas-filled ("half watt") lamps, but proper methods of shading are of vital importance in order to eliminate glare. Electric and incandescent gas lights now receive more attention from the staff and better adjustment of light to work is often noted. Mr. Eraut (Belfast) comments on the improved lighting in linen-weaving sheds and in handkerchief and embroidery work. It is remarked: "The concentration of light on the cloth is effected by means of carefully shaded electric lamps whereby the worker is protected from the glare, the reed space being thoroughly illuminated, and at the same time sufficient lighting is provided in the gangways. In fine stitching it is obvious that a very efficient system of lighting is essential if the eyes of workers are not to be strained, and this is being secured by means of lamp shades with a very acute cone angle which concentrates the light on the work immediately under the machine needle and leaves the worker's face shaded."

The high accuracy demanded in work in many factories in Coventry and Rugby likewise makes good lighting imperative, and here overhead illumination is common. The introduction of a concentrated form of lighting is reported in the Norwich boot factories, lamps being carefully shaded and attached to standards affixed to the table. As an instance of bad lighting, Miss Sanderson refers to a clothing factory where all the lamps were hung about 5½ feet above the floor level. The firm had bought new shades in the hope of relieving eyestrain, but when she pointed out that even with these shades the greater portion of the bulb of the lamp would still project below the shade, the firm discarded them and bought others of a deeper shape; even so it was found impracticable to shade all the lights satisfactorily without unduly darkening the room. This case is mentioned as illustrating the necessity of providing separate general illumination besides the lighting of individual machines or parts of the work.

Attention is also drawn to the effect of brighter decoration for factories and workshops. The customary whitewashed walls with a dark or black dado have an effect of monotony. A well-chosen colour would do much to improve the general appearance of the works, and provide more

restful conditions without undue interference with the light. Cases are mentioned of several works where care was given to this point. Thus in certain textile factories ironwork has been painted in bright and contrasting colours with excellent effect, coupled with scrupulous cleanliness of walls, floors and staircases and the polishing of all metal work. This had quite a striking influence on the general impression created by the room.

Improvements, however, do not take place automatically but are the result of constant effort. Unfortunately it seems that in some industries the standard of cleanliness has been lowered during the war, and in some of the small workshops in the East London cleaning of walls, ceilings, etc., is apt to be much neglected.

THE ILLUMINATION OF FACTORIES AND WORKSHOPS.

At the opening meeting of the London Association of Foremen Engineers, on September 4th, a lecture on the above subject, illustrated by lantern slides, was delivered by Mr. L. Gaster. After summarising developments in illuminating engineering during recent years, Mr. Gaster proceeded to explain the principles underlying successful factory lighting. Special stress was laid on the need for proper maintenance arrangements, involving the regular cleaning and replacing of lamps, etc.—a matter which frequently rested in the hands of foremen engineers. The part played by measurements of illumination, in enabling an idea to be gained of the conditions existing in different classes of workshops, was explained, and the importance of scientifically designed shades and reflectors illustrated. A warning was given against the introduction of lamps for which reflectors are unsuited, such that the filaments either project or are withdrawn into the remote interior of the reflector, thus materially altering the distribution of light.

Mr. Gaster traced the development of interest in industrial lighting, and the steps that had led to the present recognition of its value in the interests of health, safety and efficiency. An account was given of the conclusions set out in the report of the Home Office Departmental Committee on Lighting in Factories and Workshops, and of the various industrial codes in use in the United States. The hope was expressed that the recommendation of the above Committee, in favour of a general statutory provision in this country requiring adequate lighting in factories, would now be carried into effect

THE ARTIFICIAL ILLUMINATION OF OPTICAL TEST-CHARTS.

A REPORT recently issued by a Joint Committee representing the Illuminating Engineering Society in the United States and the American Ophthalmological Society, recommends that optical test-cards used in testing vision should be illuminated by a source possessing, as nearly as possible, the quality of daylight. This, it is suggested, can be done by using the special Corning "daylite" glass, either with gas or electric lamps. As a suitable equipment for the consulting room two 72-watt "daylite" lamps are recommended. The lamps are arranged in a rectangular box, the front of which contains a removable plate of frosted glass, while behind the lamps there is a concave white surface, acting as a reflector. The illumination of the test-card and the angle of inclination of the light can be adjusted by varying the distance and position of the box.

In outlining the required conditions in tests of this nature it is remarked that the illumination of the chart should be uniform and the intensity of the light should represent the maximum of the range through which illumination may vary without materially influencing the visibility of test-objects. Further, the direction at which light strikes the chart must be such that there is no direct reflection of light perpendicularly, *i.e.*, towards the observer. Two other fundamental requirements are: (*a*) the surroundings must be of a subdued hue and of an order of brightness not greater than that of a light grey surface when receiving an illumination equal to that on the test-card, and (*b*) the chart and patient must be so arranged that no light-source, window or other spot of light shall be visible to the patient when viewing the chart.

Further recommendations, now being prepared, will deal with the conditions of illumination best suited to perimeter-measurements.

THE "SAFETY FIRST" CONFERENCE.

(Held at Olympia, September 22nd, 1920.)

A NUMBER of papers, dealing with various aspects of "Safety First" methods were presented at the Conference at Olympia on September 22nd. Mr. G. N. Barnes, M.P., presided at the morning session, in the unavoidable absence of the Home Secretary, and Lord Leverhulme, President of the British Industrial "Safety First" Association, during the afternoon.

Mr. Gerald Bellhouse, C.B.E. (Deputy Chief Inspector of Factories), in an opening paper, discussed the returns of accidents for the past year, which included 1,384 fatal accidents, 40,056 accidents due to machinery, and 84,582 non-machinery cases. These were serious figures which could not be viewed with equanimity, especially as many accidents were not reportable to the Inspector and were accordingly not included. A significant fact was that one-third of reported accidents was not due to machinery at all, but rather to negligence, carelessness and want of instruction. Such cases cannot be met by stricter observance of an Act of Parliament, but they can be enormously reduced by the voluntary efforts of employers and employees. In this connection Mr. Bellhouse gave some striking figures showing what had already been done by large American concerns. After 12 years' experience in America the opinion has been formed that by a proper safety organisation 75 per cent. of accidents could be eliminated in industry. In conclusion, Mr. Bellhouse gave a brief analysis of the essential features of a successful safety organisation.

Mr. G. Stevenson Taylor, who followed, discussed in detail the construction of safeguards for machinery, pointing out the need for solid construction and avoidance of flimsy material; many machine-tool makers now embody properly designed guards as an integral part of the machine. Dr. John Bridge, in dealing with first-aid in factories, remarked that the lighting and temperature of workrooms had a great influence on the accident rate, and had not yet received the attention they deserved—more especially lighting, which was also an important factor in the production of eyestrain and headache amongst workers. Great importance must be attached to the prompt treatment of injuries, including small cuts and abrasions, with a view to preventing possible septic inflammation. Small wounds, if not so treated, may develop into serious cases. Mr. G. Havinden contended that the prevention of accidents was only part of the duty of the Safety First movement; care must also be devoted to the health of workers. In particular it is essential to arouse the interest of the worker as well as the employer. Already employers realising the importance of hygienic conditions in their workshops have given thought to questions of lighting, heating, ventilation, sanitation, etc.; but all such provisions may be defeated by the inertia of the working force. Mr. Havinden accordingly suggested measures (notices, lectures, working committees, etc.) for bringing these matters before the notice of workers.

Mr. C. K. Atkinson, Welfare Superintendent at Port Sunlight, described the educational measures undertaken for Messrs. Lever Brothers, Ltd. Bulletin boards, safety notices, etc., were distributed throughout the factory. All employees, during their first week of engagement, are assembled and addressed on the subject of safety rules, waste prevention, habits, etc. Luminous signs are hung above all railway tracks at frequent intervals, and at all crossings near cranes, etc. Every accident, however trivial, is reported to the Ambulance Brigade. Posters showing the position in regard to accidents in comparison with the corresponding period in the previous year are exhibited in the works. During the first half of the present year a substantial reduction of 20 per cent. has been made. Mr. E. Hoult (Edgar Allen & Co.) and Mr. G. Ralph (British Thomson-Houston Co., Ltd.) likewise described the safety

measures employed in their respective factories, a feature in the latter case being the careful way in which accidents are tabulated and analysed. Further communications were read by Mr. H. S. Burn (Thos. Firth & Sons) and Capt. Ingall (Loders & Nucoline, Ltd.).

The final paper, read by Mr. L. Gaster, dealt with "Lighting as aid to Safety." Mr. Gaster remarked that there was no trade or industry that was not more or less dependent on artificial light. Good industrial lighting was amply justified on economic grounds as well as essential in the interests of humanity. Figures were quoted to show how improved lighting diminishes accidents as well as leading to more rapid and efficient work. Fuller statistics were, however, needed, and he hoped that Industrial Councils, Safety Committees, and managers and foremen would make a practice of recording accidents due to faulty lighting, so that the defects could be eliminated. The matter was also of direct interest to insurance companies, who might offer more favourable rates to factories considered to be properly lighted. Mr. Gaster also referred to the proceedings at the Brussels Congress of the Royal Institute of Public Health last May, when it was stated by an inspector with special knowledge of the shipbuilding industry that the operation of the Summer Time Act had led to a marked diminution in the number of accidents. This showed the need for further improvements in artificial lighting. In conclusion, Mr. Gaster paid a tribute to the sympathetic attitude taken by the Home Office in regard to industrial lighting, and expressed the hope that the recommendation that there should be statutory powers to demand adequate lighting would be carried into effect before very long. In the educational work involved in this step such bodies as the Illuminating Engineering Society and the British Industrial Safety First Association would doubtless be glad to participate.

Lord Leverhulme, in closing the discussion, expressed his full agreement with the views expressed in Mr. Gaster's paper; and a vote of thanks to the Chairman terminated the proceedings.

CALORIFIC VALUE AND THE EFFICIENCY OF GAS BURNERS.

In a paper read before the Manchester and District Junior Gas Association, Mr. J. H. Dawe discussed some of the results of using low-grade gas, referring more particularly to its effect on domestic cooking appliances. Some data were also given for incandescent gas burners, and a series of photographs were presented to show the effect on mantles supplied respectively with gas of 290, 468 and 635 B.Th.U.'s. Observations showed that the illumination with the incandescent mantles was the same; with flat-flames, as the photograph clearly showed, the flame was much smaller and less luminous with the low-grade gas. The new conditions, involving use of low-grade gas, will therefore favour still more the use of incandescent burners to the exclusion of flat-flames.

RADIATION FROM A PERFECTLY DIFFUSING CIRCULAR DISC.

In a contribution which has recently appeared in the Proceedings of the Physical Society, Mr. J. W. T. Walsh treats mathematically the light received from a perfectly diffusing circular disc by another parallel and coaxial disc of given diameter placed at a given distance away. The conclusions have a bearing on the obscuration occurring when a shadow is cast by the negative electrode used in the searchlight beam. It would appear that in general little advantage is gained by inclining the negative electrode, as compared with the use of axial carbons, unless the negative carbon is very bulky or is so increased as to bring the obscuring object outside the angle embraced by the searchlight mirror.

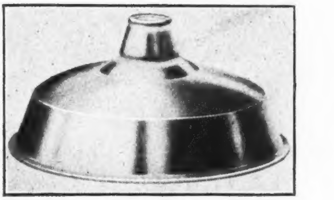
THE STANDARDISATION OF REFLECTORS FOR INDUSTRIAL LIGHTING.*

In view of the variety of industrial units now available it is natural that efforts should be made to produce standard forms of reflectors for general use, and success is naturally dependent on also securing standard dimensions for the lamps used with the reflector. A lighting unit of this description, recently described by Mr. Ward Harrison in the United States, is therefore of interest.

Numerous types of porcelain enamelled reflectors are in use, the three most common types being the flat cone, deep bowl and shallow dome. The flat cone is not in general to be recommended. A higher illumination can be obtained with other types and as the edge of the reflector falls at or above the centre of the filament there will be inconvenient glare, except when such units are used in very high rooms; in this case, however, the waste of light is very great. Various forms of "glare-shields" have been attached to such reflectors, but the use of these ring devices means that the reflecting area is small and shadows are pronounced. Such shields are regarded as emergency measures only.

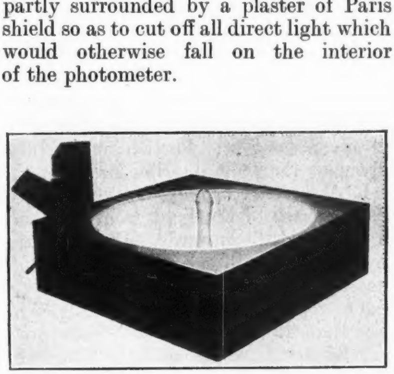
Deep or bowl reflectors give maximum shielding of the lamp filament and have been widely used. The output of typical reflectors of this type is not more than 65 per cent. Surfaces above the level of such reflectors are apt to receive an unduly low illumination and appear undesirably dark. Reflectors intermediate between the above two types may reflect 75-80 per cent. of the light from the lamp and the large area tends to soften shadows. However, with gas-filled lamps the protection from glare may be inadequate.

The "RLM" reflector now described is intended to combine the advantages of both types. It provides (*a*) a durable and efficient reflecting surface; (*b*) a contour which ensures effective light distribution, and (*c*) a depth which will cut off the filament centre from view at an angle of 72½ degrees from the vertical axis, thus reducing glare.



General view of "RLM" Reflector.

As a means of making tests on this and other reflectors the author described an interesting device termed a "reflector photometer." The photometer has a concave reflecting surface of plaster of Paris in the centre of which is mounted a concentrated filament miniature lamp supported by a plaster of Paris standard. The standard is so located that when the reflector is placed over the photometer this lamp falls in the same position with regard to the reflector as does the centre of the lamp filament when the reflector is in ordinary use. The miniature lamp is partly surrounded by a plaster of Paris shield so as to cut off all direct light which would otherwise fall on the interior of the photometer.



Photometric Device for Comparing the Efficiency of Reflectors.

* "The RLM Standard Reflector for Industrial Lighting," by Ward Harrison (Trans. Ill. Eng. Soc., U.S.A., Aug. 30, 1920).

	Various Reflectors.				RLM. Standard Dome.		
	Shallow Dome Reflector Clear Lamp.	Bowl Reflector Clear Lamp.	Metal Reflector Diffusing Silver Cap.	Opal Globe with Reflector	Clear Bulb.	Frosted Bowl.	Enamelled Bowl.
Per cent. total Lumens from Clear Lamp	—	—	—	65	—	—	—
Per cent. of total Lumens in Lower Hemisphere	77	65	55	58	75	71	65
Relative Section of Horizontal Surfaces	A	B+	B	B	A+	A	B+
Relative Section of Vertical Surfaces	A+	B	C+	B+	A+	A	B+
Direct Glare	D	C+	A	B	C	B	A
Reflected Glare	D	D	A	C+	D	C	B
Shadows	C+	C	A+	B+	C+	B	A
Maintenance	A+	A	C+	B+	A+	B+	A

A+ indicates Best. B indicates Good.
A „ Excellent. C+ „ Fair.
B+ „ Very Good. C „ Weak.
D indicates Condemned.

When the reflector is placed in position above the photometer all the light is reflected down into the plaster of Paris area, but a small portion finds its way out to a window in the side of the box, where it illuminates a translucent screen. The brightness of this screen serves as an indication of the amount of light emitted downwards by the reflector studied. It is tested by comparison with the light yielded by a second miniature lamp mounted near the window. As both lamps are run off the same voltage no voltmeter or other instruments are needed.

By this apparatus different forms of reflectors may be tested, or different kinds of surfaces used within a reflector of given contour. Particulars are also given of the light distribution from the "RLM" reflector. In a typical case, 69 per cent. of the light from the lamp is reflected downwards. For the best results clear bulb gas-filled lamps should not be used with "RLM" standard dome reflectors at mounting heights of less than 20 feet. For some reflectors a special bowl-enamelled lamp has been devised. This enamelling of the lower part of the bulb makes the unit virtually a semi-indirect bowl. It is stated to resist mechanical abrasion and to be proof against acid fumes, and to present a smooth surface which does not allow dust to collect readily.

In conclusion, some comparative data comparing this with other forms of reflectors are given. These are reproduced in the accompanying table.

ILLUMINATION AND SAFETY.

We observe that on October 22nd the New York Section of the Illuminating Engineering Society (U.S.A.) and the American Society of Safety Engineers are meeting in New York with a view to holding a joint discussion on "Illumination and Safety." An address on "The Elements of Good Industrial Lighting" will be delivered by Mr. S. E. Doane, and Mr. S. A. Hibben will deal with "Industrial Lighting Equipment and its Maintenance." We are glad to note that the part played by good lighting in factories as a safeguard against accidents is thus being brought before the notice of safety engineers.

DEPARTMENT FOR SCIENTIFIC AND INDUSTRIAL RESEARCH: REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR 1919-20.*

THE Annual Report of the Department for the past year is a comprehensive publication, and it is evident that its work is expanding steadily. After the introductory reports of the Committee of Council and the Advisory Council there are three further sections dealing respectively with: I. Industrial Research Associations; II. National Research and Development of Research in and for the Empire; and III. Aided Research, Patents, Publications of Learned Societies. The total expenditure during the year has been £330,176 2s.

An important new step is the co-ordination, in connection with the Department, of all research work of common interest to the fighting services, in which three principal boards are concerned. A new building, adjacent to the National Physical Laboratory, is to be devoted to Radio-Research. The Boards dealing with Fuel Research, Food Investigation, Tin and Tungsten Research have made good progress, and there are seventeen other researches being conducted by the Department. There are also now eighteen research associations connected with various industries—double the number existing last year. Twelve patents have been taken out by the Trust in conjunction with inventors. It is interesting to observe that the highly important question of methods of dealing with inventions made by workers aided or maintained from public funds "so as to give a fair reward to the inventor and thus encourage further effort" is being dealt with by an Inter-Departmental Committee.

Aid has been given to 20 scientific investigations (including such subjects as glass technology, hard porcelain, technical optics, atmospheric conditions in mines, etc.) conducted by other bodies: 159 grants have been made to individual researchers, the expenditure being £26,700 as compared with £12,661 4s. 1d. during 1918-19. For 1920-21, £45,000 is expected to be thus expended and the number of individual workers is steadily increasing. It is laid down that these researches must be of a kind intended to benefit science as a whole; researches of immediate industrial value are differently treated.

Another matter of importance is the increased cost of scientific publications. On several occasions important scientific documents have been issued through the Stationery Office, but this is no substitute for the increased support needed by scientific bodies in order to make results of research public on the same scale as before the war. The Department would welcome common action by scientific societies with a view to presenting a definite statement to the Government in regard to possible temporary assistance to scientific societies during the present period of unsettled prices.

It is only possible to mention briefly a few of the many researches in progress. The experiments being conducted at the East Greenwich Research Station by the Fuel Research Board are of obvious importance. The study of different varieties of coal and their carbonisation at temperatures of from 500° C. to 1300° C. has an added interest in view of the new method of charging for gas on the basis of the number of thermal units. Other inquiries relate to the use of peat and pulverised coal, and the production of alcohol for industrial purposes. In connection with the preservation of food, interesting data are being obtained on the changes that take place in meat and fish after death and in the living tissues of fruit in the process of ripening. It appears that such changes may progress at a relatively low temperature and the whole question is of great importance in connection with cold storage. A special low-temperature research station at Cambridge University is now contemplated.

A number of the leading industrial research associations are arranging to

* Cmd. 905. 1/- net. Published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C. 2. pp. 120.

build and equip special research laboratories, and in many cases a systematic tabulation of information and literature bearing on the respective industries is being undertaken. Meantime the Bureau of Records, under the Department, is already attempting, on a limited scale, to aid in the exchange of technical information and prevent the duplication of work by different bodies.

Experimental investigations are being conducted in mine-rescue apparatus and the conditions in deep and hot mines. The Oxygen Research Committee is studying the production and transport of oxygen and its applications as an aid to observers at high altitudes—for example, as an accessory to be used by an expedition to climb Mt. Kamet in the Himalayas. Other materials being studied include timber and building materials, lubricants, adhesives, various metals and optical glass. A Committee, formed under the British Scientific Instrument Research Association, is studying Anti-Glare Glass. Some interesting facts are mentioned regarding researches at the British Museum and the National Portrait Gallery. Here the presence of objects 2,000 or more years old offers special opportunities of acquiring knowledge of such matters as the decay of metals with age, the preservation of varnishes, and the removal of incrustations, etc.

DISTRIBUTION-PRESSURES FOR ELECTRICAL DOMESTIC SUPPLY.

In a recent contribution to the *Electrical Review* Mr. C. H. Wordingham contends that the ultimate development in domestic electrical supply must be in the direction of much lower pressures. The argument is based mainly on the consideration that in future electricity should be applied to many other domestic uses besides lighting, but much that Mr. Wordingham urges is also of interest in regard to illumination. In the future it seems likely that alternating current will be much more generally used than at present, in view of the ease with which it can be transformed up and down for transmission purposes.

Now experience shows that while for normal individuals 220 volts direct is safe, alternating current of this pressure has caused death, and must be considered potentially dangerous. Accordingly it seems injudicious to suggest that this pressure should be led into nurseries, kitchens, bedrooms, etc., and handled freely for other purposes than lighting. But 50 volts or even 100 volts can be regarded as safe.

It appears, therefore, that in future we shall see a return to lower pressures in the consumers' dwellings, though distribution may be effected at much higher pressures than at present, possibly 2,000–3,000 volts. At the consumers' premises this must be converted to 50 or 100 volts. Only very large users would have a special transformer for their personal use. The usual practice will probably be to attach several houses, or perhaps an entire street, to one local transformer.

Another consideration that favours the use of, say, 50 volts is the gain in simplicity in wiring, which could be done much more economically. Such a safe voltage also makes flexible connections much more judicious than at present, though there is certainly room for improvement in the conventional methods of connecting such appliances. Mr. Wordingham remarks that one great fundamental advantage of electric wiring should be the ease with which a cable can be carried round corners or past obstacles, as compared with a rigid pipe; yet, by adopting conduit systems, as is usual with higher voltages, this advantage is deliberately thrown away.

Apart from its advantages for heating, cooking, etc., this low voltage has advantages for lighting as well. It would bring low consumption gas-filled lamps of a serviceable type into much greater use, and would prove beneficial to the design of the smaller forms of lighting units, which are better adapted to domestic use. By favouring flexible connections it would also tend to make lighting arrangements more adjustable.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BRITISH THOMSON-HOUSTON COMPANY, LTD.—EXTENSIONS OF RUGBY FITTINGS FACTORY.

There is now a growing recognition of the importance of scientific methods of lighting. The chief difficulty, of late, has been to meet the demand owing to the recent diversion of the energies of leading manufacturers to war work, and the consequent disturbance in the routine of production.

In view of the rapid growth of their lighting business the British Thomson-Houston Co., Ltd., decided some months ago to extend their Rugby Fittings Factory. We are informed that the new workshops are nearing completion, and that the most up-to-date machinery is being installed. The company accordingly expects very shortly to be able to manufacture and deliver fittings and reflectors in vastly greater quantities than heretofore. One of the stable products of this factory is the Mazdalux Metal Reflector for industrial lighting, and the extended facilities will, it is hoped, enable the output of such reflectors to be trebled or quadrupled, while the production of "Eye-Rest" indirect fittings will also be considerably increased.

ANTI-VIBRATION FITTINGS.

The Engineering and Lighting Equipment Co., Ltd., send us particulars of a new pendant gallery fitting incorporating the anti-vibrator discs, which are claimed to prevent breakage of lamp filaments, even under the most trying conditions. The discs are composed of two concentric rings of phosphor-bronze gauze, within which the lamp is suspended.

"POINTOLITE" LAMPS.

A new catalogue dealing with the well-known "Pointolite" (arc-incandescent) lamps has been issued by the Edison Swan Electric Co., Ltd. These lamps, as is well known, furnish light from an incandescent globule of tungsten within a sealed glass envelope, constituting a "point-source" which is well adapted for use with microscopes, reflecting galvanometers and other laboratory instruments involving optical projection. In addition to the familiar 100 c.p. lamps we note that small 30 c.p. 0·45 amp. galvanometer lamps are listed. Another new feature is the 1,000 c.p. three-electrode lamp which is stated to consume only 0·42 watts per candle in the lamp. This new form of lamp, which was shown at the opening meeting of the Illuminating Engineering Society last year, is considered specially suitable for projection work, owing to the combination of high candlepower with comparatively small generation of heat. A 500 c.p. three-electrode lamp is also shown.

The normal intrinsic brilliancy is stated to be about 12,000 c.p. per sq. in. with the two-electrode lamp, and 16,000 c.p. per sq. in. with the three-electrode lamp, but the brightness can be varied between wide limits, the limiting intrinsic brilliancy when the globule is molten being as much as 60,000 c.p. per sq. in.

INDUSTRIAL AND STREET LIGHTING FITTINGS.

INDUSTRIAL and street lighting, which are dealt with successively in the new catalogue of fittings recently issued by the General Electric Co., Ltd., are undoubtedly two of the most important fields of illuminating engineering. In the solution of such problems the selection of suitable fittings plays an important part, and as many installations are now undergoing revision the issue of this catalogue is timely.

Several introductory pages are devoted to illuminating engineering data, particulars of the illumination desirable for various processes and the watts and lumens available from standard types of lamps being given. Next there are illustrations of some typical lighting installations, both streets and factories. These include some factories equipped with Benjamin fittings and views of street lighting in Manchester. The accompanying illustration is interesting, showing the use of semi-indirect fittings in a motor works.

Showing Conditions of Illumination in the Vauxhall Motor Co.'s Works.

Particulars are next given of standard types of industrial units and reflectors, hand-lamps, well glass fittings, etc. A variety of weather-proof lanterns for street and yard lighting is next shown. Most of these can be equipped with opalescent globes—a desirable step with half-watt lamps. We are glad to see that the description of the "City" lantern is accompanied by a polar curve of light distribution based on tests by the N.P.L., and that a focusing arrangement is provided to ensure the correct position of the filament in the reflector. The "Metropolitan" lantern, also illustrated, utilises the Holophane Refractor glassware. Following this, data relating to various accessories are given, one feature being the G.E.C. time switches which are suitable for controlling public clock lighting, staircase lights, luminous devices used in shop windows after closing time, etc.

INDEX, September, 1920.

THE DOMINIONS TOURING EXHIBITION (1921).

We understand that the Department of Overseas Trade is organising the Dominions Touring Exhibition with the object of fostering and developing trade with the Dominions. The exhibition will carry to South Africa, Australia, New Zealand and Canada specially selected samples of British manufactured goods. A booklet issued by the Department contains particulars of types of goods in request. The scheme will be self-supporting, 500 units of space being allotted, for which applications may be made. It is understood that the Inland Revenue Authorities will regard the cost of participation in the tour as advertising expenses. It is interesting to observe that facilities are being provided for the use of films to illustrate goods and processes, and for this purpose a Demonstration Kinema Lorry and a number of portable projectors will accompany the exhibition.

Full particulars can be obtained on application to The Secretary, Dominions Touring Exhibition, Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1.

DEPARTMENT FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

The Department of Scientific and Industrial Research announces that a licence, under Section 20 of the Companies (Consolidation) Act, 1908, has been issued by the Board of Trade to the British and Electrical and Allied Industries Research Association, which has been approved by the Department as complying with the conditions laid down in the Government Scheme for the encouragement of Industrial Research.

The Association may be approached through E. B. Wedmore, Esq., Electrical Research Committee, c/o Electrical Development Association, Hampden House, 64, Kingsway, W.C.2.

The Report of the Enquiry Committee on the Standardisation of the Elements of Optical Instruments, now published for the Department by H.M. Stationery Office, deals with a variety of interesting topics, including units of measurement, objectives for telescopes, prisms for binoculars, mirrors for sextants, screw threads, gear teeth, etc. Copies (1s. each) may be obtained through H.M. Stationery Office, Imperial House, Kingsway, W.C.2.

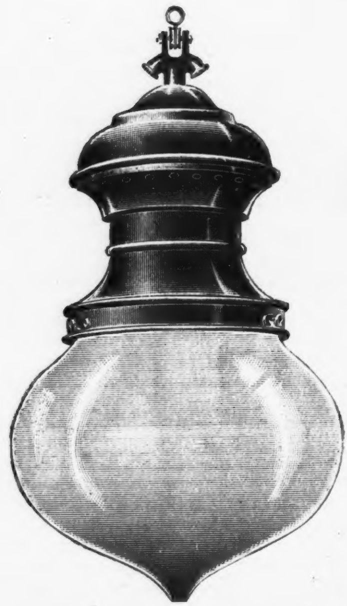
LAMPS AND LANTERNS FOR OUTDOOR LIGHTING.

WE have received from Messrs. Falk, Stadelmann and Co., Ltd., two recently issued catalogues (Nos. 442 and 456) dealing respectively with the "Ukay" gas lamps and various lanterns for "half-watt" and vacuum electric lamps —both suitable for outdoor use.

The "Ukay" Lamp.

Readers will recall that early in the present year * a reference was made to the series of "Ukay" gas lamps introduced by Messrs. Falk, Stadelmann & Co., Ltd. The features of these lamps, equipped with superheater and of substantial and simple design are illustrated in catalogue No. 442. A point of interest is the use of clusters of mantles, which is decidedly advantageous in cases where the full lighting is not invariably employed. As there is every indication of a revival of outdoor shop-front lighting during the present season the issue of these catalogues is opportune. We should, however, like to utter a caution against the indiscriminate use of bright unscreened units at a low level outside shops. Types of lamps fitted with a parabolic reflector directing the light into the window and screening it from the eyes of passers-by are illustrated in both catalogues, and we commend this form of unit to shopkeepers in all cases where the low level of suspension might otherwise give rise to an impression of glare.

A variety of lanterns for electric lamps, some suited for clusters others for single lamps, is shown, and a special feature has been made of adequate ventilation. We may also draw attention to the pedestal-type of lantern involving a diffusing globe mounted on an ornamental metal standard which may be effectively used outside public buildings, and deserves to be more widely known. The catalogue contains particulars of bracket lamps and other special designs in which wrought ironwork is employed, and a page is devoted to cast iron columns suitable for outdoor lighting.



Efesca Outside Lantern ("Bedford Type").

* ILLUM. ENG., Jan., 1920, p. 19.

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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

OFFICIAL ORGAN OF THE

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EDITORIAL.

Illuminating Engineering Departments and Public Service.

One of the most striking developments in the policy, both of companies concerned with the supply of gas and electricity and firms interested in the manufacture of lamps and lighting appliances, has been the recognition of the obligation to render service to the public. The broad view that should be taken of such obligations was admirably expressed by Mr. F. W. Goodenough in a paper read at the recent conference of the British Commercial Gas Association. The leading gas companies, we believe, fully recognise the desirability of making friends with the consumer by offering him the best advice on the use of gas for lighting and other purposes, and we hope that the public endorsement of this policy will influence those companies who still fall behind this high standard. Future developments in conditions of electric supply should enable these undertakings also to do more to assist the consumer.

The adoption of this policy of giving good service involves the instruction of a staff of assistants in the best methods of using light

hygienically and efficiently, and the organisation of what is, in effect, an illuminating engineering department. Firms concerned with the manufacture of lamps and lighting accessories have possibly an even more direct incentive to establish departments of this kind. Unless they receive good advice and assistance, consumers naturally do not use lamps and reflectors in the best way, and are disposed to blame the articles supplied when the method of employing them is really at fault.

It is common knowledge that a number of leading firms have established illuminating engineering departments during recent years, and that others who have not formally done so also recognise the need of giving advice. What we wish to emphasise, however, is that the announcement on the part of firms that they are prepared to give such advice carries with it definite obligations. Unless there is available accurate information regarding the effects to be obtained with various lighting fittings, and unless a firm possesses assistants with a proper knowledge of illuminating engineering, their offers of assistance may prove misleading, and they will reap no permanent benefit from their efforts to aid the consumer.

Offers of assistance, therefore, should be conditional on a trained staff and the equipment of a suitable laboratory in which accurate tests of lighting appliances can be made and reliable data obtained on their performance in practice. It is also most desirable that there should be a general understanding on the main principles to be recommended, so that the public may not be confused by contradictory advice. These principles have been consistently elucidated by the Illuminating Engineering Society during the last twelve years, and we hope that all firms and companies who aspire to advise the consumer will follow the lead of most of the best known companies by making the staff of their illuminating engineering departments members of the Society. The participation of such assistants in the work of the Society has already done much to promote uniformity in recommendations on lighting, which would be aided still further by frequent conferences of firms manufacturing lamps and lighting appliances, and companies engaged in the supply of gas and electricity.

These remarks apply with special force to undertakings concerned in the supply of both gas and electricity, and therefore in a position to apply either in the cases where it is most advantageous to the consumer. In the United States this condition frequently prevails, and supply companies take an active part in the work of supplying consumers with lamps and lighting appliances, and advising them on their use. Accordingly, such undertakings form one of the most important sections of the supporters of the Illuminating Engineering Society. At the present time the need of good advice is particularly felt by the consumer. The introduction of the Gas Regulation Act will doubtless bring new problems, and the consumer must be able to rely on the help of gas companies in obtaining advantageous lighting under the new conditions of supply. In electric lighting again the increasing use of gas-filled lamps will only prove of real value to the consumer if he is shown how to use them wisely. Consumers must be educated to appreciate that the lamps selected should be suitable for the fittings with which they are used. In some cases a lamp of the proper shape can be used with existing reflectors, in others new and specially designed fittings are needed.

To sum up, the aim both of supply companies and of makers of lamps and fittings should be to ensure *good lighting*—a condition which is only achieved when expert advice on the use of illuminants is available.

The Measurement of Absolute Coefficients of Reflection.

The measurement of the absolute coefficients of diffuse reflection of surfaces has always been regarded as a somewhat complicated and difficult photometric problem, although purely relative values may be obtained by the aid of an illumination photometer with comparative ease. Apparently this country was one of the first to deal with the problem. Dr. W. E. Sumpner's results, published as far back as 1893, have been the subject of frequent reference. It will be recalled that Dr. Sumpner found for white blotting paper a coefficient of reflection of 82 per cent., and it has been generally assumed hitherto that the highest value of diffused reflection obtainable from a dead white surface was not far removed from this figure.

Within recent years, however, a number of experiments on the determination of reflection-factors have been made in the United States. Some of these are summarised in valuable paper recently published by Mr. A. H. Taylor, of the Bureau of Standards (Washington), with which we deal fully in the present issue (pp. 265—269). Progress in this field has been greatly expedited by the use of the integrating sphere. The calculations underlying Mr. Taylor's method may appear somewhat involved, but apparently the actual procedure is not unduly difficult. More recently Dr. C. H. Sharp and Mr. W. F. Little have presented a paper before the American Illuminating Engineering Society describing another integrating sphere method which seems to have the merit of extreme simplicity.

The scientific importance of such investigations is obvious, and it may be added that they also fulfil a useful practical purpose in filling a distinct gap in our knowledge of the amount of light reflected from various surfaces in interiors. The important part played by reflection from walls and ceilings in most lighting installations is hardly sufficiently appreciated. Fuller knowledge on this subject may enable us to forecast illumination more exactly than at present, and it would be of great assistance to lighting experts to have available a series of specimens of typical surfaces, with their reflection factors attached, such as have already been tentatively prepared in the States.

One interesting side-issue in Mr. Taylor's paper is the preparation of a series of neutral-tinted surfaces of graded reflecting power. Much remains to be done in regard to the best method of preparing such standard surfaces, especially in regard to permanency, but once the method is standardised they would prove of considerable value in photometry. Another feature of Mr. Taylor's work that deserves comment is his determination of the coefficient of reflection of magnesium carbonate as near 99 per cent. This result appears to be in good agreement with that arrived at independently by other observers, but it is naturally surprising to find that even freshly prepared magnesium carbonate reflects light as perfectly as this. The whole subject certainly deserves further investigation, and we hope that it will receive attention from photometric experts in this country.

Standards of Industrial Lighting.

The most recent addition to the series of States in America that possess legislative codes on factory lighting is Oregon, and in the present issue (pp. 273—274) we deal with a recent article by Mr. F. H. Murphy summarising its principal recommendations, and comparing them with those of California, Wisconsin, Ohio, Pennsylvania, New Jersey and New York.

As regards standards of industrial lighting the Oregon code is in general agreement with that of other States, though slightly differing in detail, and also in harmony with the official code of the American Illuminating Engineering Society. One point insisted upon, however, is that the mere provision of sufficient illumination is only a part of adequate factory lighting; avoidance of glare, inconvenient shadows, etc., is equally important. Accordingly the bulletin issued by the State of Oregon is so arranged as not to give undue prominence to the detailed values of illumination set out for various processes. Let it be clearly understood that such schedules of illumination are of the utmost value. But this value is only completely realised when the other requirements as regards proper shading and positions of sources of light, etc., are also complied with.

One highly important clause in the Oregon code is that specifying that the Commissioner of Labour and Inspector of Factories "shall be guided by the best engineering practice as set forth in the recommendations of the Illuminating Engineering Society." The method by which the correct principles of factory lighting is established by the experience and experiments of the Society, and finally made use of in the legislative codes, seems to be a highly desirable one, which might well be borne in mind in other countries. In this way the groundwork of recommendations on industrial lighting can be readily established, and the detailed requirements of various industries could be settled by conference with the representatives of the chief trades concerned.

Naturally experience in the United States has shown the need for very full explanatory data in regard to the various codes, so that the States make a practice of issuing bulletins in which, besides the actual wording of the code, useful information on the best means of complying with it, descriptions of measuring apparatus, and explanations of technical terms are given. It is also to be noted that there exist in most countries bodies whose co-operation would be beneficial in making requirements of factory lighting widely known, and drawing attention to their importance from special aspects. Thus in this country the British Industrial "Safety First Association," which has already identified itself with the cause of good industrial lighting in the interests of safety, could doubtless render valuable aid in this respect.

Another series of standards of lighting has been adopted by the Illuminating Engineering Society in Germany (pp. 275—276) Although intended to apply to interior lighting generally and not exclusively to factories, these values seem in fair agreement with those adopted in the United States. Here, also, care is taken to specify conditions in regard to avoidance of excessive brightness and contrast, etc., as well as actual values of illumination. As stated in our last issue, we understand that the subject of industrial lighting is to receive attention from the section on industrial hygiene under the League of Nations at Geneva, and it is evident that there is now growing up a set of principles which may pave the way ultimately for an international code on industrial lighting

L. GASTER.

MEASUREMENT OF DIFFUSE REFLECTION FACTORS, AND A NEW ABSOLUTE REFLECTOMETER.*

By A. H. Taylor.

I. Introduction—Nature of Reflection.

The reflection factor of a surface is defined as the ratio of the total luminous flux reflected by the surface to the total luminous flux incident upon it. No surface obeys the cosine law of emission perfectly, and most surfaces are very far from being perfect diffusers.(1)

The numerical value of the reflection factor of a surface may depend on the colour of the incident light and the manner of its incidence. The determination of reflection factors with precision is one of the most difficult feats in photometry, and previous methods besides being complex have not been sufficiently accurate.

II. Earlier Reflectometers.

Any method of measuring reflection factors must inevitably involve an integration of the reflected flux. This practically limits the method to some application of the integrating sphere.

Apparently the first definite proposal of an instrument for the measurement of diffuse-reflection factors was made in 1912 by Dr. Nutting.(2) His instrument consists of a highly polished nickeled ring through which projects the nose of a König-Martens polarisation photometer. An illuminated diffusing glass plate is placed on one side of the ring and the test surface on the other, and the photometer is arranged to view the two surfaces at an angle of about 75° from the normal. He describes it thus: "The principle of the method is that of two parallel infinite planes, one of which is a diffuse illuminator and the other the surface whose reflecting power is to be determined. The relative brightness of the two planes is then the reflecting power of the non-luminous plane." Since the planes are not infinite and no surface exactly obeys the cosine law of emission, the method is inaccurate and there are other sources of uncertainty.

A method devised and used by Mr. W. F. Little(3) at the Electrical Testing Laboratories consists in the projection of a beam of light through a small hole in the wall of an integrating sphere on to the test surface, placed near the centre of the sphere. The brightness of the observation window when the test surface is in place, compared with that when the standard surface is used, is substantially the same as the ratio of the reflection factors of the two surfaces. A slight modification would make it an absolute method. If the light beam is first projected on to the sphere wall at a point unscreened from the observation window, and is next projected on to the test surface, screened from the window, the ratio of the brightness of the window in the second case to that in the first case is the numerical value of the reflection factor of the test surface. The area of the test surface should be small with respect to the sphere surface. Another method of using the sphere would be to determine the reflection factor of its surface by a method which will presently be described, then to determine the relative values of test and sphere surface by projecting the beam first on one, then on the other, the illuminated spot being screened from the observation window in each case. The greatest practical difficulty in the application of these methods of using the sphere is the realisation of a narrow beam of light which is of a sufficiently high intensity and at the same time is so concentrated that none of it is incident anywhere except on the test surface. The modifications of Mr. Little's methods pointed out by the author require the sphere surface to be uniform in reflecting power.

* Abstract of Scientific Paper No. 391, issued by the Bureau of Standards, Washington.

In 1916 Dr. Rosa [4] and the present author described and applied a method of measuring the reflection factor of the surface of an integrating sphere. It consists in the determination of the ratio of the average illumination received by the sphere surface from the test lamp to the total illumination of the sphere surface by both direct and reflected light, the numerical value of this ratio being the absorption factor of the sphere surface. The absorption factor of an 88-inch sphere at the Bureau of Standards, when the surface was fresh, was found to be 7·5%. Since magnesium oxide and carbonate have long been considered, and probably are, the whitest substances in existence, this test set the lowest possible limit for their reflection factors, and indicated that the value of 88%, given by Dr. Nutting's reflectometer, was considerably in error.

amount of specular reflection of the object, but it is probable that this error would not be very large. The instrument will, however, give incorrect results if the standard surface is incorrectly evaluated.

III. The New Absolute Reflectometer.

In 1916 the author worked out the complete theory of a reflectometer which was to be an absolute instrument.

At the convention of the Illuminating Engineering Society in Chicago, in Oct., 1919, it was pointed out that the value of 88% for magnesium carbonate was much too low, and the author briefly described the instrument now explained more fully.[6] The author has also stated that the reflection factor of magnesium carbonate was approximately 96%.

The reflectometer consists of a small sphere arranged as shown in Fig. 1.

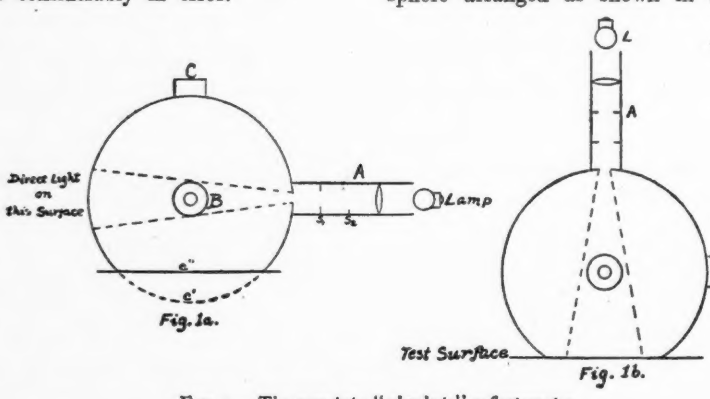

FIG. 1.—*The new type "absolute" reflectometer*

In 1917 Mr. M. Luckiesh[5] described a new relative method for measuring reflection factors. An opal glass globe, such as is used in lighting fixtures, is mounted in a white box and is surrounded by four or more lamps, symmetrically placed. The globe has an opening at the bottom, against which is placed the object to be tested. A brightness photometer views the test object, its brightness being compared with that of a standard surface of known reflection factor. The results of tests with this instrument may be in error because of the fact that the photometer views the test object at a fixed angle, and that the brightness at that angle may depend very largely on the

Light from a small lamp is projected through tube A on to the inner sphere wall. At *B* is a small hole through which the opposite wall can be viewed by a brightness photometer. The segment of sphere surface c' is cut off by a plane, leaving the opening c''. The test surface is placed over this opening, and the direct light is projected on to the sphere wall or the test surface, depending on whether the lighting tube is placed at *A* or *C*. The attachments are so constructed that their positions are interchangeable. In the experimental instrument constructed and used in the tests the area c', the portion cut off, was 10% of the total sphere area.

IV. Theory of Reflectometer.

If a plane surface is illuminated by an infinite plane of uniform brightness b (candles per unit area), the flux received by unit area of the illuminated plane is πb lumens. A perfect diffuser of uniform brightness b emits πb lumens per unit area.

The interior illumination of a hollow sphere with diffusely reflecting walls may be considered as composed of two parts: (a) The light received directly from the light source, and (b) the illumination made up of light diffusely reflected from the sphere walls. The part (b) is the same in value at all points in an empty sphere, in accordance with the theory of the integrating sphere.

Assume the hollow sphere arranged as shown in Fig. 1a. Let the area of the complete sphere be unity.

Let c' = ratio of sphere area cut off to total sphere area.

Let c'' = ratio of area of hole to total sphere area.

Let $a = 1 - c'$ = fraction of total sphere area which remains.

Let m = diffuse reflection factor of sphere surface.

Let m_x = diffuse reflection factor of test surface.

Let F = total light flux (lumens) received from lamp.

Let b_0 = average brightness (candles per unit area) of sphere wall due to *reflected light only* when hole is uncovered.

Let b_x = brightness when hole is covered with a flat test surface having a diffuse reflection factor m_x.

Let b = brightness when test surface has reflection factor m.

In the original paper the author then analyses the conditions when the hole is uncovered and the part removed is replaced by the test surface. He thus arrives at the relation :—

$$b_x = \frac{m^2 F(a + c' m_x)}{\pi[c'' m(1 - m_x) + a(1 - m)]} \quad . \quad . \quad (1)$$

It is possible to measure the relative brightness of the sphere wall under various conditions and thus m and m_x can be computed. If $b/b_0 = K$, and $b_x/b_0 = K_x$ then it is shown that :—

$$m^2[c'(c'' - a) + Kac''] + ma[c' + (c'' - a)(1 - K)] + a^2(1 - K) = 0 \quad . \quad . \quad (2)$$

and

$$m_x = \frac{a(K_x - 1)[c'm + a(1 - m)]}{ac'(1 - m) + mc''(c^1 + K_x a)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

These equations assume apply to the case where direct light is incident on the sphere wall. However the instrument is more accurate if the direct light is incident on the test surface. Hence we may first use the former arrangement and determine m from equation (2) and then adopt the second method (shown in Fig. 1b); by using a suitable reference standard it is then possible to evaluate absolutely the reflection factor of any test surface. A rough surface milk glass makes a satisfactory reference standard, as it is easily cleaned. If R = value of brightness of sphere surface when the aperture is covered with surface m'', *divided by* the corresponding brightness when the surface m' is used, it can be shown that :—

$$m'' = \frac{Rm'[a + m(c'' - a)]}{a(1 - m) + c''m(1 - m' + Rm')} \quad . \quad (4)$$

and when $m'' = m$, then

$$m'' = m_x = \frac{Rm[a(1 - m) + mc'']}{[(1 - m)(a + c''m) + Rm^2c'']} \quad (5)$$

V. Experimental Results.

In order to verify the theory of this instrument a graded series of test objects was made up. Neutral grey objects were obtained by mixing black drawing ink and lampblack with a white cement (Keene's Fine). They were surfaced with coarse sandpaper, resulting in fairly good diffusers. Those having reflection factors below 50 per cent. were better diffusers than those above that value. The gray objects, after having been made up for about four or five months, were found to have faded somewhat, and hence are not satisfactory for permanent reflection factor standards.

The test objects were next tested for reflection factors by means of point-by-point observations. The amount of flux reflected was then calculated by applying the proper factors, and since the incident flux was known, the ratio of the reflected to the incident flux gave the reflection factors of the test surfaces.

A number of the cement standards and a block of magnesium carbonate were measured by both methods of using the instrument as described above. By the use of equation (2) the reflection factor of the sphere surface was found to be 88·3%. This value was then substituted in the equation and the reflection factors of the various test objects were computed. The results of the measurements in the three different ways are shown in Table 1.

TABLE I.—REFLECTION FACTORS BY THREE METHODS OF MEASUREMENT.

Test object.	Point-by-point measurement.	Sphere reflectometer measurements.	
		Direct light on test objects.	Direct light on sphere wall.
	Per cent.	Per cent.	Per cent.
Cement Standard 1..	17·7	18·4	21·9
Cement Standard 2..	23·7	23·95	28·2
Cement Standard 3..	31·5	31·6	35·2
Cement Standard 4..	36·3	37·1	39·6
Cement Standard 5..	42·9	42·9	46·4
Cement Standard 6..	60·0	60·7	62·8
Cement Standard 7..	67·4	67·3	70·2
Cement Standard 8..	81·9	81·4	82·7
Cement Standard 9..	86·5	85·5	86·8
Cement Standard 10..	90·8	90·4	89·6
Magnesium carbonate	99·3	99·1	98·7

The agreement between columns 2 and 3 is almost perfect, and for reflection factors above 80% the fourth column is in satisfactory agreement. At least a part of the discrepancy may be attributed to experimental error. The author has made up paints having a factor of about 94%, which would be much better for this application.

The measurements by the three methods give about 99% for magnesium carbonate, whereas the previously accepted value was only 88%. It did not seem possible that its value could be so high, and steps were taken to verify it by a fourth absolute method, which was described above as a modification of the sphere method used by Mr. Little. This measurement gave a factor of 98·9% which, on the basis of the consistency of the photometric readings, appeared to be thoroughly reliable. Hence it appears that the reflection factor of this particular block of magnesium carbonate is 99%. Another block, obtained about three weeks later from the same source, has a factor of approximately 98%, while another block which has been in the laboratory for about two or three years is appreciably darker than either of these. No investigation has been made of the reproducibility of such surfaces for precision standards. Magnesium carbonate is not a perfect diffuser, hence this must be taken into account if it is desired to use it as a standard of surface brightness.

VI. Effect of Specular Reflection from Test Surfaces.

As mentioned above, the surfaces with which these tests were carried out were fairly good diffusers. Some other surfaces which have been examined by point-by-point measurements have been ordinary semimat surfaces. The difference between the surface brightness of the test surface at 50° and a perfect diffuser emitting the same total flux rarely exceeds 3 to 5% and is usually below 3%. The effect of a deviation of 5% from perfect diffusion at 50° for a surface of reflection factor 80% has been calculated for a reflectometer having 10% of its area cut off, and painted with a paint having a reflection factor of 90%. The calculation shows that the error of the determination would be less than 0·50%. Hence the error of determination due to specular reflection will not exceed 2% in a reflectometer having these dimensions, unless an excessive amount of the specular reflection of direct light is incident on the observation window. This will not hold true unless the specular reflection takes place only at the first surface.

The reflection factor of a mirror may be determined by first directing a narrow beam of light into the opening of the reflectometer, then allowing the same beam to be reflected from the mirror and to be directed into the reflectometer when the mirror is placed at an appreciable distance from the reflectometer. The ratio of the brightness of the observation window in the second case to that in the first will be the reflection factor of the mirror.

VII. Precautions in use of Reflectometer.

In the use of the reflectometer as described above certain precautions are necessary. Some of them are as follows :

(*a*) The dimensions should be precisely determined in order to fix the values of the constants c', c'', and a.

(*b*) In painting the sphere and the flat surface by means of which its reflection factor is determined, care must be taken to make the flat surface as nearly as possible the same in reflecting power as the sphere surface.

(*c*) When calculating the reflection factor of the sphere surface by the use of the equation (2), the figures should be carried out as far as possible, as a small error in calculation may make an appreciable error in the result. The use of logarithms for this step is recommended.

(*d*) When the direct light is incident on the sphere wall, care must be taken to prevent any direct light from escaping through the large opening c''.

(*e*) Few, if any, paints will remain absolutely constant in reflecting power, hence the reflection factor of the sphere surface, when once determined, should not be assumed constant thereafter but should be checked frequently. This can be done by means of test objects standardised when the paint in the sphere is fresh. Depolished milk glass is excellent for this purpose, and white blotting paper would probably be satisfactory. If a sufficient number of such objects, covering a wide range of reflection factors, were standardised very carefully when the surface was fresh, they could be used to establish an empirical calibration of the reflectometer at any time, without the necessity of solving the mathematical equations.

VIII. Conclusion.

In conclusion the most important points brought out by this paper may be summarised as follows :—

1. Five "absolute" methods of measuring reflection factors are described, at least three of which are apparently new. Measurements on magnesium carbonate by four of these methods give values which are in excellent agreement.

2. The numerical value of the reflection factor for magnesium carbonate which has been in use for many years—viz., 88%—is in error. The actual value of its diffuse reflection factor is approximately 99%, but the degree of reproducibility of this value with materials from different sources is unknown.

3. The method described above for the use of an incomplete sphere as a reflectometer furnishes two new absolute methods for the determination of diffuse reflection factors. The determination of the reflection factor of the sphere surface is only an incidental step in the use of the instrument, and is not its principal object.

4. The instrument just described should find a large field of usefulness in photometry and illuminating engineering, and furnishes a method of measuring the reflection factors of surfaces *in situ*. Apparently no other instrument has been proposed for this purpose which is accurate and portable. It can be adapted for use with any good type of portable photometer.

5. It should be strongly emphasised that the reflection factor of any *coloured* surface is dependent on the colour of the incident light and that measurements by this or any other method will give its reflection factor only under the particular conditions of the test. Hence under such conditions the principal value of the measurement is to indicate the approximate value of the factor, but this is all that is usually required.

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SOME RECENT DEVELOPMENTS IN LIGHTING AT WATERLOO STATION.

THE lighting arrangements at a large railway terminus frequently present interesting features, illustrating how structural considerations affect the disposition of the lights. Escalators, or moving staircases, are typical cases. The problem may be distinctly different when the staircase is enclosed in a tube, as on the underground railways, from that presented by an escalator contained in a lofty chamber (part of it with temporary roofing) as is at present the case at Waterloo Station.

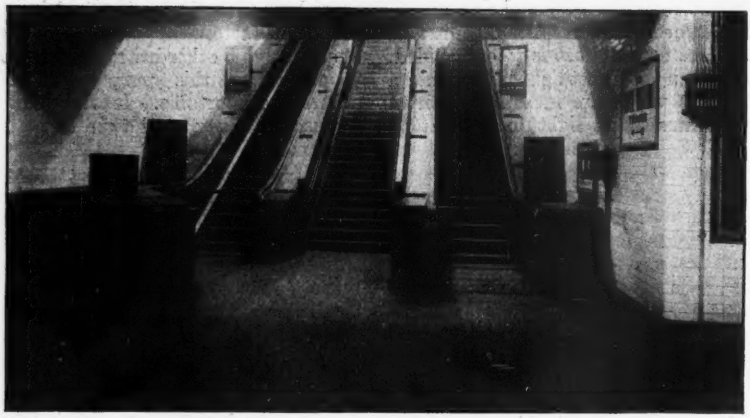

FIG. 1.—Showing view of Escalator taken from the bottom.

(A) *The Lighting of the Waterloo and City Escalator.*

This escalator has only been in use a comparatively short time, and by the courtesy of the Chief Engineer of the London and South Western Railway we are able to give some particulars of the present system of lighting designed by Mr. A. Cunnington, the Company's Lighting Engineer. Fig. 1 shows a general view of the escalator from the bottom, where descent is made to the Waterloo and City Railway. The method of lighting the moving stairs cannot be seen in this view, although the photograph gives a good idea of their appearance when lighted. The actual measured illumination on the stairs is about 1 to 4 foot-candles, and appears ample. Attention may be drawn to the two bowls at the entrance. These are necessary for the purpose of giving extra illumination at the points where passengers enter and leave the staircase, and their presence also makes a considerable difference to the general effect, which would otherwise appear rather flat.

The actual illumination of the stairs is afforded by two diffusing glass bowls containing respectively three 100-watt and three 300-watt gas-filled lamps. It was necessary to arrange for the lamps to be in series owing to working at 600 volts. There is also an emergency series of three lamps in the bowl near the top of the escalator run on a separate circuit, so that in the event of a failure of the ordinary lighting taking place, when the escalator is crowded with people, the emergency circuit would be available. The bowls are well out of the range of view (in fact, so high as to be only with difficulty included in the field of the camera), and as they are mounted below a white surface the effect is quite soft and free from glare. Both are visible in Fig. 2, which was taken from half-way down. It is interesting to

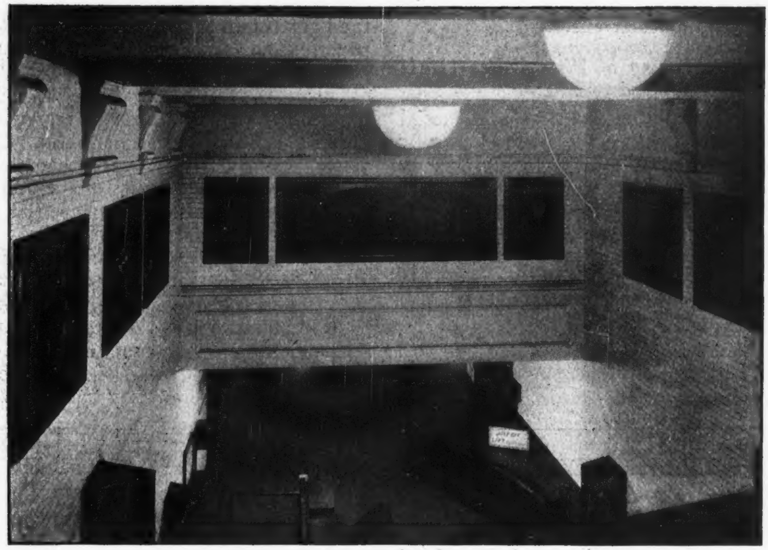

FIG. 2.—View, looking down from half-way up the Escalator, showing the two Bowls overhead.

note that, by the use of three times as much candle-power in one bowl as in the other, it has been found possible to get a fair degree of uniformity in illumination, in spite of the distance of the treads from the source of light being so different at the top and bottom of the escalator. The diffusion of light is much aided by the white tiled surroundings, and the various advertisements and pictures not only

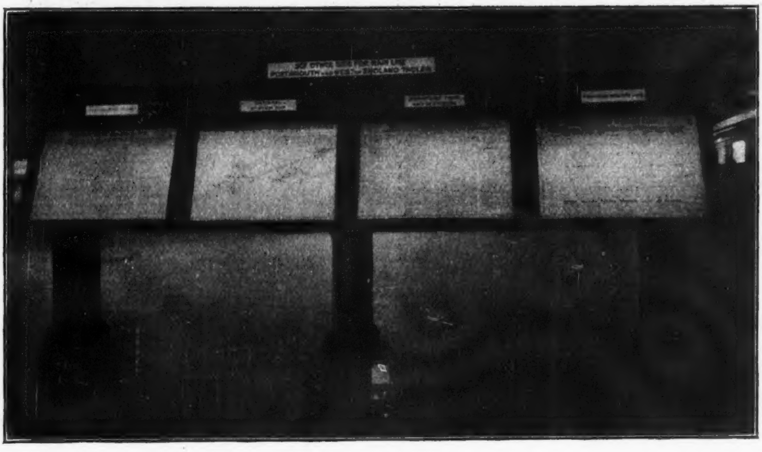

FIG. 3.—Showing Time Tables at Waterloo Station, illuminated by transmitted light from lamps inside the frame.

help to break up the monotony, but have even a spectacular effect.

(B) *The Lighting of Time Tables (Main Concourse).*

We recently referred to the special method of lighting these time-tables by means of transmitted light. Fig. 3 shows the sloping racks on which the time-tables and maps are mounted. They are protected by glass covers and receive light from lamps inside. The conduit carrying the mains to these lamps runs up on the extreme right of the rack. The brightness of the surface is about 4 equivalent foot-candles and the figures can be seen with ease. Apart from the high illumination readily secured by this means, there is the advantage that as the light comes entirely from behind the paper, there is no question of shadows being cast by the observers' body, a difficulty that is almost sure to arise when an attempt is made to rely upon general lighting for time-tables. The whole arrangement is very economical, only twelve 20-watt lamps being required to light eight time-tables, three lamps to each pair of time-tables. Finally there is the incidental merit of the arrangement that the brightness naturally attracts the attention of people, who might otherwise have to inquire where the time-tables are situated. It was, in fact, apparent on the occasion of our visit that the racks are very well patronised by the public.

ROYAL SOCIETY OF ARTS.

LECTURE ARRANGEMENTS FOR THE SESSION.

THE series of lectures arranged by the Royal Society of Arts for the next session contains some interesting items. On November 24th, Dr. F. W. Edridge-Green will lecture on "Colour Vision and Colour Blindness," and after Christmas there is to be a paper read by Sir Herbert Jackson on "Research in Scientific Instrument Making."

The Cantor Lectures comprise the following:—

A. Chaston Chapman, F.R.S., F.I.C., on "Micro-Organisms and some of their Industrial Uses." (Three lectures.) November 29th, December 6th and December 13th, 1920.

Eric K. Rideal, M.B.E.M.A., D.Sc., Ph.D., F.I.C., on "Application of Catalysis to Industrial Chemistry." (Three lectures.) February 14th, February 21st and February 28th, 1921.

Major C. W. C. Kaye, D.Sc. (National Physical Laboratory), on "X-Rays and their Industrial Applications." (Three lectures.) March, 7th, 14th and 21st, 1921.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.C. (Lecturer in Spectroscopy at University College, London), on "Recent Applications of Spectroscopy and the Spectrophotometer to Science and Industry." (Three lectures.) April 11th, 18th and 25th, 1921.

THE USE OF ULTRA-VIOLET LIGHT IN TREATING DISEASES OF THE EYE.

IN the "British Journal of Ophthalmology" Mr. T. Harrison Butler summaries some recent experiments of Birch-Hirschfeld on the application of ultra-violet rays to the treatment of diseases of the cornea. While the harmful effect of excessive ultra-violet light, which may be responsible for conjunctivitis, retinitis, cataract and keratitis is confirmed, the rays may nevertheless be used with good effect for the treatment of certain skin diseases and infections of the mucous membrane. Twelve years ago Hertel used the cadmium-zinc lamp, which furnishes intense ultra-violet rays, for the treatment of serpent ulcer and obtained good results.

Birch-Hirschfeld, not having a cadmium lamp available, used a small arc lamp fitted with uviol glass screen and quartz lens. The first experiment was not successful, as the ulcer continued to spread. But when the cornea was sensitised with a 2 per cent. solution of fluorescein, whereby the absorption of ultra-violet rays was increased, much better results were secured. Of 40 cases so treated only six failed to receive benefit. No trace of ophthalmia electrica (inflamation of the eyes caused by the rays) was observed, because the short wave-length light was concentrated only on the ulcer and not upon other tissues.

THE INDUSTRIAL LIGHTING CODE OF OREGON, U.S.A.

IN the *Electrical World* Mr. F. H. Murphy gives a summary of the industrial lighting code adopted by Oregon, the latest American State to introduce legislation on factory lighting. The provisions follow closely those adopted in other States, and, consequently, are in substantial agreement with the code originally drafted by the Illuminating Engineering Society (U.S.A.); however, Oregon has been able to benefit by the experience of other States and has introduced a few modifications. These are indicated in the accompanying table, which contains a list of the values of illumination prescribed by the various States that have so far adopted lighting codes.

In view of the necessity of providing a means for altering prescribed values of illumination without it being necessary to invoke repeatedly legislative aid, the following section was introduced into the Act:—

"The Commissioner of Labour and Inspector of Factories and Workshops of the State of Oregon is hereby authorised to establish certain minimum values for lighting, which shall be deemed proper and adequate in accordance with the conditions set forth in this Act. In arriving at what values shall be used in this schedule of minimum lighting, and such rules as shall determine definitely what shall constitute compliance with the provisions of this Act, he shall be guided by the best engineering practice as set forth in the recommendations of the Illuminating Engineering Society. Before such schedules and rules, however, shall become effective the Commissioner of Labour must, upon his own motion, appoint a commission of three persons, one to represent the manufacturing interests, one to represent the operating electrical workers, and one must be an electrical engineer. Notice of the public meetings of such commission shall be published in the leading newspapers of each county of the State, giving the time, place and purpose of such meetings. The Commission shall have power, after the holding these public meetings, to establish, to rearrange or to readjust the schedule of lighting values and rules as set forth above. These rulings or readjustments shall then become effective thirty days after they have been made and the Commissioner of Labour shall serve notice, in writing or by publication in the leading newspapers of each county of the State, of the rulings thus made and of the date upon which they become effective."

It will be observed that, according to this section of the Act, the Illuminating Engineering Society (U.S.A.) is recognised as the standard authority on the matter of illumination values. The Legislature, at a special meeting held in January, 1920, also passed a Bill authorising the State Industrial Accident Commission to establish all necessary and reasonable safety rules, proper regulations and provisions, and providing for the enforcement of such orders and decisions by the Commissioner of Labour.

The rules follow closely those adopted by other States. The chief modification is the adoption of 2 ft. candles under classification (F), for the reason that it was felt that there would be difficulty in practice in discriminating between classifications (F) and (J). The minimum of 0·5 ft. candle for the general lighting of workrooms (D) is intended to ensure against the extreme contrasts in brightness such as may occur when local lighting is used. Rules are also included providing for emergency and pilot lights, and

for the periodical inspection and cleaning of lighting equipment and windows.

The bulletin issued by the State of Oregon contains four sections. The first part sets out the legislative rules, and the second part is devoted to a detailed discussion of each rule so as to render it quite clear and comprehensible. This section also contains general discussions on glare, on methods of using natural light to the best advantage, and proper spacing and heights of suspension for artificial light-sources. A table is included showing the wattage per square foot corresponding with three standard types of lighting equipment and for illuminations from 0·02 to 25 foot candles. The third part of the bulletin contains a number of illustrations showing typical lighting installations, and the fourth part a table of lighting intensities for various industrial processes. Besides the values under the code upper limits indicating "productive intensities" are given.

There has been a feeling that the inclusion of large tables of lighting intensities tends to over-emphasise the importance of illumination values as compared with certain other rules, as, for example, the elimination of glare. In the Oregon bulletin an attempt has been made to overcome this objection by emphasising the other special features of the rules, such as elimination of glare, selection of proper lighting equipment, etc., and by placing the table of lighting intensities at the back of the bulletin, where it does not overshadow the other features of the code. The Bureau of Labour proposes to make a survey of lighting conditions in the industrial plants of the State, and to carry on an educational campaign as the best means of securing compliance with the law.

COMPARISON OF LIGHTING CODE REQUIREMENTS IN VARIOUS AMERICAN STATES.

	1917.	1919.	1919.	1918.	1919.	1918.	1918.	1919.
	Illum. Eng. Soc. (U.S.A.)	Oregon.	California.	Wisconsin.	Ohio.	Pennsylvania.	New Jersey.	New York.
Classification :—								
(A) Roadways and yard thoroughfares	0·02	0·02	0·02	0·25	0·02	0·02	0·02	0·02
(B) Storages spaces	0·25	0·25	0·25	0·25	—	0·25	0·25	0·25
(C) Stairways, passage-ways and aisles	0·25	0·25	{0·25 / 0·50}	0·25	0·25	0·25	0·25	0·25
(D) General lighting for work rooms..	—	0·50	0·25	—	—	—	—	—
(E) Toilets, washrooms, water closets, dressing rooms and elevator cars..	—	1	{0·25 / 0·50}	0·50	0·50	—	—	—
(F) Rough manufacturing, such as rough machinery, assembling, bench work or foundry floor work	1·25	2	1	1·25	1	1·25	1·25	1
(G) Fine manufacturing, such as fine lathe work, pattern and tool making and light coloured textiles	3	3	3	3	3	3	3	3
(H) Office work, such as accounting, typewriting, etc.	3	3	3	3	3	3	3	3
(I) Special cases for fine manufacturing, such as watch making, engraving, drafting and dark coloured textiles	5	5	5	5	5	5	5	5
(J) Rough manufacturing, involving closer discrimination of detail than (F)	2	2	2	2	2	2	2	2

STANDARDS FOR THE LIGHTING OF INTERIORS.

A COMMITTEE formed by the Illuminating Engineering Society in Germany (Kommission für praktische Beleuchtung) has recently issued a series of recommendations relating to the lighting of interiors, an account of which has appeared in the *Elecktrotechnische Zeitschrift* (July 15th, 1920).

The recommendations are arranged in several groups and are substantially as follows :—

I.—ADEQUACY.

(1) Every area must receive suitable illumination, according to the purpose for which it is intended. A distinction is drawn between general illumination and special or working illumination (Platzbeleuchtung). General illumination is necessary in rooms of all kinds and may also constitute the working illumination. In other cases extra working illumination is necessary.

Minimum values of illumination are as follows :—

(A.) *General Illumination, i.e.,* illumination necessary to facilitate freedom of movement (Verkehrsbeleuchtung) is measured on a horizontal plane one metre above the floor, and should attain :—

	Lux*
(A) In areas of relatively small importance	1
(B) On landings, staircases, etc. ..	5
(C) In occupied rooms, working rooms used by a number of people	10

(B.) *Working Illumination, i.e.,* the average illumination measured on the working surface or place where work is done, should attain :—

	Lux*
(D) For Rough Work	10
(E) For Writing and Reading ..	25
(F) For Drawing, Embroidery, Watchmaking and fine mechanical work..	50

The above values are to be regarded essentially as *minima,* and should be considerably exceeded in practice. Any diminution in illumination arising from deposits of dust on lamps and lighting appliances, deterioration of lamps, etc., should not be so high as to bring the actual illumination below the minima prescribed above.

(2) General illumination should neither be completely diffused (shadowless), nor should it be such as to give rise to inconvenient shadows on the floor, walls or objects in the room.

(3) No considerable variation in illumination should occur over the working area and there should be no fluctuations (flicker, etc.) in the source of light such as are liable to cause fatigue.

(4) Abrupt variations in the amount of illumination in different rooms should preferably be avoided.

(5) When daylight is being exclusively used the daylight factor (*i.e.,* the ratio between the working daylight illumination and the illumination derived from the unrestricted sky-surface) should not be less than 0·5 per cent.

(7) With a view to securing good lighting conditions in important buildings it is recommended that an illuminating engineer should be consulted when the plans are being prepared.

II.—CONSIDERATIONS OF HEALTH.

(1) The eyes of workers should be protected from dazzle due to direct or reflected light.

(2) Local lamps for individual workers must be so screened that the brightness does not exceed 0·75 candle (Hefner) per sq. cm.

(3) For general illumination lamps of greater brightness may be used. But the brightness must not exceed 5 candles (Hefner) per sq. cm., if the sources are so placed that the angle between the line from the eye to the source and the horizontal plane is less than 30°; in other cases these light sources must also be screened or enclosed in light-diffusing globes.

(4) Prejudicial collection of products of combustion and undue development of heat should be guarded against by suitable ventilation.

* N.B.—One Lux (Hefner-metre) = 0·084 international foot-candle.

III.—EFFICIENCY.

In so far as the conditions prescribed under I. and II. can be complied with in various ways, the most efficient arrangement should be adopted.

IV.—ÆSTHETIC CONSIDERATION.

Installations should be carried out with due regard to artistic effect, but correct principles of illumination should not be sacrificed thereto; in the design of lighting installations in public buildings an architect should be consulted.

THE DEPARTMENTAL (HOME OFFICE) COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

THE Departmental Home Office Committee on Lighting of Factories and Workshops has now resumed its investigations. The work was temporarily abandoned after the publication of the Committee's first report, owing to the unusual conditions prevailing during the war. Additional members have now been appointed to the Committee, which is now constituted as follows:—

Sir Richard Glazebrook, K.B.E., F.R.S. (Chairman); Mr. Leon Gaster (Hon. Secretary of the Illuminating Engineering Society): Prof. C. S. Sherrington, D.Sc., P.R.S. (Prof. of Physiology, University of Oxford); Mr. J. H. Parsons, D.Sc., F.R.C.S. (President of the Illuminating Engineering Society); Mr. W. C. D. Whetham, F.R.S. (Trinity College, Cambridge); Sir Arthur Whitelegge, K.C.B.; Dr. C. S. Myers, C.B.E., F.S. (Director of the Physiological Laboratory, Cambridge); Miss R. E. Squire, O.B.E. (H.M. Deputy-Principal Lady Inspector of Factories); Mr. D. R. Wilson, M.R. (Secretary of the Industrial Fatigue Research Board).

The Committee hopes to arrive at definite standards of illumination requisite for various types of work, and to extend the field of inquiry so as to include industries not previously investigated.

The Secretaries to the Committee are—Mr. J. W. T. Walsh, M.A., M.Sc., of the National Physical Laboratory, Teddington, and Mr. H. C. Weston, M.J.Inst.E., Investigator to the Industrial Fatigue Research Board, to whom communications should be addressed at the offices of the Board, 6, John Street, Adelphi, W.C.2.

PROGRESS IN INDUSTRIAL LIGHTING.

IN reading a paper on the above subject before the Association of Engineers in Charge on October 13th, Mr. Gaster recalled the historic discussion before the Association on December 11th, 1907, when he delivered a paper on "The Province of the Illuminating Engineer." At that time the conception of "illuminating engineering" was comparatively new and not generally understood, but subsequent years had shown that the proposals then made were quite practicable. The following year (1908) saw the starting of THE ILLUMINATING ENGINEER, and in 1909 the Illuminating Engineering Society began its work. Great advances in knowledge of lighting had since been made. Measurements of illumination were now familiar, and leading firms concerned with lamps and fittings now habitually furnished polar curves of the lighting units they produced.

In the field of industrial lighting progress had been especially rapid. Mr. Gaster referred to the various international congresses at which this subject was discussed, to the work of the Departmental (Home Office) Committee on Lighting in Factories, and to the various codes of industrial lighting set up in the United States. A large number of slides were shown illustrating statistics on the relation between illumination and health, safety and efficiency of work, and showing typical modern lighting installations. In conclusion Mr. Gaster pointed out that engineers in charge could render most valuable assistance by collecting information on cases in which bad lighting had caused accidents, or suggesting arrangements of lighting adapted to special industrial processes. The Illuminating Engineering Society would welcome their attendance at meetings and also any suggestions regarding subjects which afforded profitable ground for further investigation.

Mr. Haydn T. Harrison, who presided, likewise referred to the progress of the Illuminating Engineering Society and expressed the hope that industrial lighting would be closely studied by engineers in charge.

AN INTERESTING CHURCH LIGHTING INSTALLATION.

BY AN ENGINEERING CORRESPONDENT.

THE artificial illumination of churches, especially those where the architectural features have that beautiful simplicity associated with the Early English period, has proved one of the most difficult problems which the modern illuminating engineer has had to solve.

Such a case occurred lately in the ancient City of Canterbury, where the Church of St. Dunstan's, one of the first resting-places of the Canterbury Pilgrims who flocked to do penance at the shrine of St. Thomas à Becket, has lately been converted from gas to electric light.

The rector and churchwardens, desiring to obtain the best results of modern illumination, consulted Mr. Haydn Harrison, M.I.E.E., who advised the use of direct concealed lighting in order that the architectural features should not be marred by any fittings of modern design.

The beautiful result is clearly shown in the illustration, the illumination obtained is of a high standard, being from 2 to 3 foot-candles, the expenditure of energy being 0·3 watt per square foot of floor area, which high efficiency is obtained by the use of gas-filled lamps in combination with suitable reflectors.

View of the Church of St. Dunstan's, Canterbury, taken by the artificial light provided.

The installation has been excellently carried out by Mr. S. Terry of that city. The wiring was done in a very short time, and at a cost much lower than that which is generally expended upon the garish installations which so often disfigure some of our most beautiful buildings.

THE DISTRIBUTION OF LIGHT AND SPHERICAL REDUCTION FACTORS OF ELECTRIC INCANDESCENT LAMPS.*

By M. IGARI (Physicist of the Research Laboratory of the Tokyo Electric Co.).

IT has long been usual to express the light yielded by electric incandescent lamps in terms of the so-called mean horizontal candlepower. The introduction of the gas-filled lamp, however, has shown the desirability of giving values in terms of total flux of light or mean spherical candlepower. With such varied forms of filament, values of horizontal candlepower are misleading as a basis of comparison. It would therefore be helpful to know the spherical reduction factors for various forms of filaments, enabling horizontal c.p. to be converted into mean spherical c.p. or *vice versa*.

The factor may be ascertained either by applying the Rousseau construction (or its equivalent) to the polar curve of light distribution, or by means of the Integrating Sphere Photometer. In the original paper the author describes this familiar construction, and mentions that values with the integrating sphere have also been obtained.

Tests were made on a series of 19 types of lamps (13 of the "Mazda B" and five of the "Mazda C" type, and one carbon filament lamp), some having clear bulbs and others frosted ones. Five to ten lamps of each type were tested.

The following values are mentioned as typical:—

Type of Lamp.	Spherical Reduction Factor.
100 v. Mazda B ..	0·780
100 v. Mazda C (Flood Lighting)	0·854
100 v. Mazda C ..	0·978
100 v. Mazda C (Ring filament)	1·117

These differences are due to the variety of form of filament. The ordinary straight filament resembles in light-distribution a glowing vertical line. The polar curve in this theoretical case would be given by $I_\theta = I_n \sin\theta$ where I is the horizontal intensity. This is the equation of a circle. The spherical reduction factor for such a line source is $\pi/4$ or 0·785.

On the other hand the light-distribution from a horizontal ring filament is represented by:—

$$I_\theta = \frac{2I_v}{\pi} \mathrm{E}(\mathrm{Sin}\,\theta)$$

where I_v is the candlepower vertically downwards, $\mathrm{E}(\mathrm{Sin}\,\theta)$ an elliptical integral of the second order. The spherical reduction factor of such a source is theoretically 1·234.

Mazda B lamps approach closely the first case of a vertical luminous line and Mazda C the second case of a horizontal luminous ring. Intermediate conditions, *e.g.*, zigzag filaments, also exist.

The shape of the bulb has also an appreciable influence on the spherical reduction factor. Experiments with straight-sided (S) and globular (G) bulbs show, on the average, the following results:—

$$\frac{\text{Spherical Reduction Factor of S Bulb Lamp}}{\text{Spherical Reduction Factor of G Bulb Lamp}} = 0{\cdot}96.$$

Comparisons were also made between clear and frosted bulbs, experiments showing that the ratio of the mean spherical candlepowers in the two cases is 0·91, *i.e.*, 9 per cent. of the total light is absorbed through frosting. The distribution of candlepower is also altered. Generally speaking the effect of frosting is to smooth out irregularities in the curve of light distribution.

* Abstract of a paper read before the Illuminating Engineering Society of Japan.

THE VISIBILITY OF RADIATION.

The Proceedings of the Japanese Physical and Mathematical Society for September, 1920, contained a contribution by Mr. Masamichi So on the "Visibility of Radiation." The results of tests of 21 observers are summarised, and it appears that the curve of distribution of luminosity through the spectrum is substantially the same as that obtained by various workers in the United States. It is interesting to note this agreement between American and Japanese eyes.

PROGRESS IN LIGHTING.*

New Developments in Theory and Practice.

By W. E. Bush (Illuminating Eng. Dept. British Thomson-Houston Co., Ltd.).

Much has been said and written on the subject of artificial lighting, but it is doubtful whether much of this information is generally understood, except by the few whose business is concerned with the advancement of lighting. For centuries light has been treated in such a casual manner that it is difficult to make people realise, without introducing technicalities, that there is "more in it." Until a few years ago the sole criterion by which artificial lighting was judged was the candlepower of the lamp. Nowadays this rule-of-thumb attitude is giving place to a more scientific conception of the function of artificial lighting. It is now understood that candlepower is merely the basis of calculation; the thing that matters is the effective illumination over the area (or throughout the space) where light is needed. The lower the candlepower of lamps used to obtain this desired result the better.

Mr. Bush then proceeded to explain the basis of calculations of illumination, defining such terms as horizontal candlepower, mean spherical candlepower and the lumen. The conception of the lumen, as the flux of light corresponding with the reception of an illumination of one foot-candle over an area of one square foot, or as 4π times the mean spherical candlepower, can be readily explained by considering a model hollow sphere, having at its centre a small glow lamp of one candlepower, and a detachable portion one square foot in area, forming $\frac{1}{4}\pi$ of the whole superficial area of the sphere. Mr. Bush also illustrated the treatment of flux of light by the analogy of a pool of water.

* Abstract of a paper read before the National Association of Supervising Electricians on December 14th, 1920.

Mr. Bush next exhibited a simple form of "foot-candle meter" using a scale having a number of translucent spots of graded brightness situated in a white strip of paper, which receives the illumination to be measured. The illumination can then be read off by inspection of the scale without its being necessary to manipulate the instrument to obtain balance. The limits of the scale are 0·05 to 25 ft.-candles, and the light is derived from a small glow lamp under one end of the scale, receiving current from a dry cell. A voltmeter and rheostat enable the voltage to be adjusted to the correct value for which the instrument was originally calibrated. Such an instrument can be readily carried about for checking the illumination in different interiors, for which the lecturer suggested the following values :—

General office lighting ..	5	ft.-candles
Drawing office	8	,,
Machine shop	5	,,
School classrooms ..	4	,,
Weaving shed	4	,,
General store illumination	5	,,
Operating tables ..	30	,,

Apart from the useful illumination received on the working plane, it is important to know the percentage of the total light furnished by the lamps falling on the working plane, the "utilisation-factor," which is expressed in the relation : Total light in lumens = intensity in foot-candles × area in square feet/utilisation factor. This enables the total lumens required in a room to be determined, after which the choice of fittings and their arrangement must be studied. The lecturer briefly referred to direct, semi-indirect and indirect lighting, and the methods adopted of spacing the lighting units and selecting their height, a

typical example being worked out. The requirements in a good lighting installation may be briefly stated to be: Efficiency, uniformity, diffusion, eye-protection (*i.e.*, elimination of glare). An important element in factory lighting is the relation between conditions of illumination and production. The results of improved lighting, namely, better conditions, health, better workmanship, fewer accidents and decreased spoilage, all tend towards the desired end—increased production.

Bush said a few words on the lighting specification of the future, pointing out the desirability of insisting upon a guarantee of intensity and uniformity of illumination—a condition already prescribed by some consulting engineers, factory managers, and Government Departments. Ultimately minimum values of illumination in factories will probably be specified by statute.

In conclusion, Mr. Bush dealt briefly with various problems in illumination, such as the lighting of churches, picture

FIG. 1.—Factory showing illumination of Sewing Machines by means of Local Reflectors and Lamps.

galleries, offices, shop-windows, and interiors, and factories. His remarks were illustrated by views of a number of typical lighting installations. By the courtesy of the British Thomson-Houston Co., Ltd., a few of these illustrations are here reproduced. The first illustration shows a factory in which local shaded lamps are employed, while in the other two installations effective use is made of indirect methods of lighting, respectively by bowls and by lamps concealed in special trough reflectors.

It is well known, moreover, that lighting forms only a small proportion of the total cost of production. The lecturer illustrated this by considering the total running expenditure involved in a lamp and reflector used for 300 working days, showing that the cost of lighting amounted to £2 3s., as compared with a cost of labour (8 hours per day for 300 days at 2s. 6d. per hour) of £300, that is about 0·7 per cent.

In the latter part of the lecture Mr.

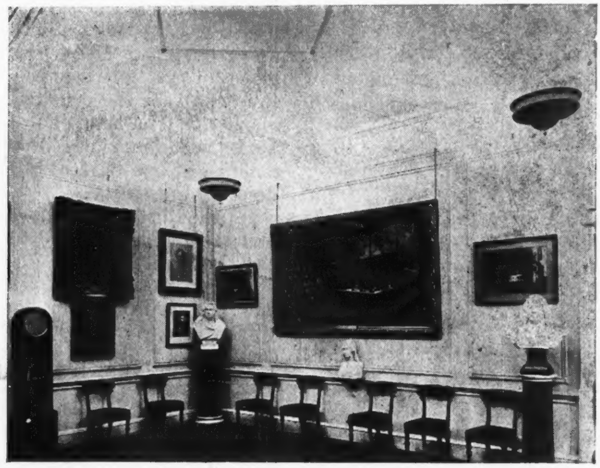

FIG. 2.—Indirect Lighting in the Royal Institution of Great Britain.

FIG. 3.—Showing the Church of Sacred Heart, Donnybrook, illuminated by Concealed lamps in Trough Reflectors.

DISCUSSION ON ELECTROPLATING.

A joint meeting, organised by the Faraday Society and the Sheffield Section of the Institute of Metals, was held in the Mappin Hall of the Department of Applied Science of the University of Sheffield, St. George's Square, on Friday, November 19th, to discuss papers dealing with various aspects of electroplating.

GAS FITTINGS IN NEW HOUSES.*

In a paper before the Midland Union Gas Association, Mr. A. Hill recently discussed various questions arising out of the supply of gas to workers' new houses, such as are being provided by authorities in various towns. It is pointed out that gas is very largely used in such houses and that the satisfaction of the consumer depends greatly on the way in which the house is piped. In Birmingham a specification relating to internal piping has been prepared for the use of architects and builders. The service-pipe is laid up to 30 ft. to each house if this specification is complied with ; up to September 30th 8½ per cent. of houses could not be passed as complying with the specification.

Mr. Hill's remarks referred chiefly to six-room houses. According to the specification all supplies are taken through a ¾-in. main ; running separate heating and cooking-lighting services is advantageous, but cost is an item to consider. The B.C.G.A. specify ⅜-in. pipes for pendants, and the Birmingham specification requires that no pipes less than ½-in. diameter are to be laid horizontally under boards. The position of the meter deserves consideration ; it is sometimes put in a box and placed in the corner of the largest living room, which is safe and convenient, but open to possible objection on æsthetic grounds. Some difference of opinion seems at present to exist regarding the size of meter, which, for reasons of cost, should not be greater than strictly necessary. It is common practice to assume that the meter will not have to take more than two-thirds of the total capacity of apparatus installed ; but some assume that all such apparatus may be used at the same time.

In the six-room house, occupied say by man and wife and one child, there are seven lighting points, apart from gas fires and cookers. A debatable point is the choice of pendants or brackets for bedrooms. With electric lighting, pendants are general, but it is found that consumers prefer brackets for gas lighting. The height of brackets is laid down in the specification as 6 ft. to 6 ft. 3 in. This assumes the use of inverted mantles (the quality of gas is unsuitable for flat flame burners). The ceilings in the new houses are 8 ft. high. If the bottom of the globe of an inverted pendant is 6 ft. from the floor the pendant itself will be about 1 ft. 3 in. long, and the mantle will be 21 in. from the ceiling ; the desirability of some form of ceiling protector deserves consideration.

In the discussion it was considered preferable, in the better class of house, to have separate supplies for heating and lighting. It was also suggested that brackets were preferable for the lighting of bedrooms, as this made it easier for the consumer to alter the position of his furniture.

* *Gas Journal*, Nov. 17, 1920.

THE USE OF GREEN LIGHT IN GLASS-BLOWING WORKS.

By an Engineering Correspondent.

Visibility for glass-blowing can be improved in daylight by filtering out the red rays by glazing the existing windows with green-coloured glass, thereby eliminating interference with the self-luminous red rays from radiant heat sources, so producing greater clarity of vision and producing a greater contrast in the appearance of metal when seen respectively in the hot and the cold states. This fact is illustrated by the adoption in some works of this description of Cooper Hewitt mercury vapour lamps in which the (in this case) objectionable red rays are lacking. The high luminous efficiency (approx. 6 candle-power per watt) of these lamps and the good diffusion of light are also advantages.

Where electricity is not available the same principle can be applied by colouring the globes. It is essential that this colour-correction should be made at the source. Tinted spectacles which come between the work and the eye and entirely obliterate the red rays are naturally useless.

The system of glazing the window glass a green colour should also commend itself, as the difference between the cost of ordinary window glass and the coloured glass, is the sole expense incurred.

GAS IN RELATION TO THE HOUSING PROBLEM.

WE notice in the *Gas World* an account of a lecture recently delivered by Mr. F. W. Goodenough at a meeting of municipal and county engineers held at the Beckton works of the Gas Light and Coke Company. Mr. Goodenough, in his introductory remarks, emphasised the important part played by good lighting as a factor in health. Much has been done during recent years to remove dangers to health, but we have yet to do all we can to prevent the "diseases of darkness," *i.e.*, the diseases which flourish where sunlight penetrates not. With a view to the prevention of pollution of the atmosphere he welcomed the opportunity of putting before municipal engineers the case for making provision for the use of gas for heating, cooking, and lighting in homes erected for the working classes under municipal housing schemes. This case rested on the benefit to the health of the community arising from prevention of the smoke nuisance, the need for providing for the working classes a higher standard of living, the need for economy in the use of the nation's coal resources, and the ensuing economy in building construction. So far as lighting is concerned, gas and electricity were of equal merit when judged by national considerations. Heat wasted in converting coal into electricity was nearly counterbalanced by waste involved in turning the heat of gas into light. Mr. Goodenough quoted the familiar results obtained by the late Prof. Vivian Lewes and Dr. S. Rideal affecting the choice of gas and electricity for lighting from the hygienic standpoint.

There was little to choose between the two illuminants in respect of health. In regard to cost, gas was cheaper than electricity, but the greater ease of control of the latter partially counterbalanced this difference. One interesting point was that many consumers valued highly the greater amount of heat given out by gas lighting as compared with electricity. The illuminant besides lighting the rooms also serves partially to heat them.

In any case tenants must have gas supplies available for heating, cooking, washing, etc., and the occupants of houses erected under municipal schemes were not disposed to instal a separate electrical service for lighting. No one recognised more clearly than he did that there was a big field for electric light; but that field did not include the great majority of houses covered by the municipal housing schemes of to-day.

Mr. Goodenough also laid stress on the great saving in the cost of building construction arising from the substitution of flues suitable for gas fires, in place of the much larger flues required for coal fires. Investigations in 1919 showed a saving of £45 per cottage of four rooms against which £15 might be put for the provision and fixing of the necessary gas appliances. Mr. Swain, architect to Messrs. Rowntree, of York, had independently estimated the gross saving at £42, or 5,000 bricks per cottage.

In the discussion Mr. W. R. Davidge, of the Ministry of Health, referred to the problem facing many authorities in deciding the relative claims of electricity and gas. Most electricity undertakings had been willing to meet part of the initial cost. He also wished to express his appreciation of the way in which gas companies carried out their business.

A number of borough engineers who joined in the discussion gave their experience of municipal housing schemes. Mr. Scorgie (Hackney) contended that in Hackney electricity was cheaper than gas for lighting. If gas was used for heating and cooking it was still necessary to run separate mains for lighting. The housing

boards with which he was connected had practically agreed to the house with all gas except for the living room. Mr. F. Wilkinson (Willesden) believed in electricity for lighting, but it was doubtless more expensive for heating. He had gas fires in every room but one in his house. He also referred to the effect of gas-lighting on decorations.

The President of the Institution, Mr. James Thomson, said that they had tried both electricity and gas in Dundee, and were not yet satisfied. They were now trying out special houses, one with gas and one with electricity. They were also trying a scheme for a continuous supply of hot water from a communal laundry at 2s. 6d. a week.

Mr. Goodenough, in reply, said that he did not propose for the working man an entirely gas house, as he could not afford to use gas all day. Coal or coke was suggested for the living room fire. He agreed that in the comparative repair of a house as between the use of gas and electricity there was some difference in favour of electricity. But in any case frequent whitewashing of the type of houses and tenements now being erected was desirable. He thought that the cost of lighting with electricity in Hackney was greater than gas lighting, even though the price of electricity was very low. In regard to the stocking of coal, a combination of gas and electricity undertakings would present advantages.

Central heating, about which Mr. Thomson had spoken, was not suitable in the southern parts of the British Isles, where the weather was continually changing. In these circumstances a system of heating which could be quickly put into operation was needed.

THE LIGHTING OF A LONDON COUNTY COUNCIL ESTATE.

An interesting situation has arisen in connection with the London County Council housing scheme at Becontree, in the Ilford and Barking districts. According to the *Gas World*, the Housing Committee inquired into the adoption of either (1) the use of gas to the exclusion of electricity, (2) the use of electricity for lighting and gas for heating and cooking, and (3) the lighting of some of the houses by electricity and the remainder by gas. It was found that the cost of installation of electric light would be heavy, and that additional expenditure would be involved in the higher prices charged by the Gas Light and Coke Company for supplying gas for heating and cooking if only electric light was employed.

The Committee accordingly proposed, as a general principle, that electricity should be used for lighting purposes in the streets at Becontree having sites fronting thereon available for leasing, and in the buildings abutting on such streets; and that for the present gas should be used on the remainder of the estate. The Committee further recommended that an agreement should be entered into with the Gas Light and Coke Company (1) for the supply of gas for heating and cooking purposes only to houses to be lighted by electricity (not exceeding 25 per cent.), the Company providing gas cooker and water heater in consideration of the Council supplying two built-in fires in houses having more than four rooms, and making a capital payment of £8 per house; and (2) for the supply of gas for lighting, heating and cooking purposes to the remaining 75 per cent. of houses completed, the company supplying all necessary fittings for lighting and cooking, including gas cooking stove and water heater, and piping to two gas fires in each house, in consideration of a capital payment of £5 a house, and the Council supplying two built-in gas fires in houses having more than four rooms.

THE MAINTENANCE OF LIGHTING INSTALLATIONS.

It is interesting to note that the Commonwealth Edison Company of Chicago maintains lighting units for nearly 37,000 customers at a fixed rate per lamp per month (varying from 37 cents to 1½ dollars per unit).

The Company cleans the lamps, globes and reflectors at least once a month, and where special factory conditions require more frequent cleaning it makes a practice of cleaning the lamps twice a month without extra charge.

THE DESIGN OF GAS SHOWROOMS.

At the recent B.C.G.A. Conference, Mr. H. Austen Hall, F.R.I.B.A., gave a lantern lecture on the design, planning and equipment of showrooms. He pointed out that the arrangement of many gas showrooms was badly conceived, ceilings being hidden by hundreds of pendants of different design massed together. The effect of these unsuitable methods of display was depressing, and gave the public no idea of the charm which suitable fittings should possess in their own homes. His idea of a good showroom was that it should be designed to express the beauty of good lighting within surroundings which enhanced the value of the fittings without competing with them in interest. It was the *application* to life of the inventions in the gas industry that reached the public mind, and not the mere exhibition of numberless types of stoves or lamps, which were more properly confined to the stockrooms adjoining the show room.

THE OPPORTUNITIES AND OBLIGATIONS OF A GREAT PUBLIC SERVICE.

In a paper under the above title read at the recent Conference of the British Commercial Gas Association, Mr. F. W. Goodenough laid stress on the importance to gas companies of maintaining a high standard of public service. It had been well said that "we make our money out of our friends; for our enemies never willingly deal with us." One could only make friends with consumers by giving them good service in every sense of the term. "By supplying gas of consistent and adequate quality and pressure; by ensuring that they have suitable and economical gas-consuming appliances, properly fixed and efficiently maintained; by treating every complaint made as having for its origin either fault on your part or misunderstanding on that of the consumer; by taking as your motto and ensuring that your staff take it as theirs the facts that 'the consumer pays wages, salaries and dividends—the satisfied consumer is the best advertisement—it is our business to satisfy the consumer always . . . ' you will make friends of the consumer-public, because you will have served the public well."

By the use of adequate, persistent, well-convinced and well-executed publicity, on the broadest plan, backed up by courteous efficient service one could secure the maximum possible development of an undertaking at the least possible cost.

THE INFLUENCE OF QUALITY OF GAS ON BURNERS.

Some interesting questions were recently raised by Mr. J. Jamieson, the President of the Western District of the Scottish Junior Gas Association in a recent address. It is stated that gas of only 400 B.Th.U. can be delivered without increasing the complaint list (though the *Gas World* in commenting on this matter emphasises the distinction between "gross" and "nett" values). Indeed, Mr. Jamieson has apparently found that such low grade gas gives better results than high grade gas in incandescent burners. The question is, however, whether these better results involve a higher consumption.

In particular Mr. Jamieson urged on makers of burners the need for developing types suitable for use with low grade gas. A special case was afforded by units for stair and passage lighting where only one cubic foot per hour is used. It was stated that the Greenock Corporation was obliged to have a burner and mantle made to specification as there was no burner on the market suitable for use in this way with low grade gas.

SILENT AERATED FLAMES.

THE problem of eliminating noise in gas-burners is one of great scientific interest, as well as being obviously of practical importance. In a recent lecture before the Yorkshire Junior Gas Association, Mr. Hamilton Davis describes some investigations on this point. His inquiries related primarily to burners used in gas fires, but the considerations would doubtless apply to some extent to burners used for lighting as well. Two explanations of noise have been suggested, (1) that the mixture consumed was "streaky" and combustion therefore irregular, leading to flame noise; (2) that even with a homogeneous mixture eddies may be developed in the current of the mixture, which likewise give rise to audible effects.

Mr. Davies admitted that either of the two phenomena mentioned above might cause noisiness, but he thought that there were other factors to be considered. He accordingly described some experiments, the behaviour of single flames burning from tubes of various lengths and sectional areas being examined. Separate supplies of coal gas and air, both under pressure, were mixed in a vessel packed with rolls and discs of gauze, so as to produce a homogeneous mixture in any desired proportions.

The conclusions of these experiments were summarised as follows:—

(1) The noise of an aerated flame was not necessarily due to imperfect mixing of gas and air, nor to the presence of eddies in the current of the mixture.

(2) The type of supply chamber might influence the result, but such influence, if it existed, would be constant and not invalidate the tests.

(3) A flame produced at the orifice of a single tube by the combustion of a homogeneous gas mixture was noisy if a critical consumption depending on the length and bore of the tube was exceeded.

(4) Consumption increased as length increased until a critical length was reached, after which consumption was constant.

(5) When lengths equal to or greater than the critical lengths of tubes of different diameter were compared, the consumptions producing "just silent" steady flames were nearly proportional to the diameters or internal circumferences of the tubes.

In further explanation it was stated that if more than a certain rate of mixture was consumed the differential value between the velocities of the central and peripheral streams was disturbed, and an unstable state existed, oscillations arising which ultimately gave rise to noise.

THE USE OF ELECTRICITY IN GAS WORKS.

ONE of the most interesting developments in recent years has been the increasing use of electricity in a modern gas works, which formed the subject of a recent paper before the Institution of Electrical Engineers. Originally applied mainly in connection with automatic stoking machinery, coal conveyers, etc., electric motors have been extended to pumps, washers and other appliances, and it was stated that there is one gas company which uses in its works as much as a million units per year, generated on the premises. One interesting special instance of electricity proving of service to gas works is to be found in a new electrical device for measuring the flow of gas, which seems likely to enable the gas engineer to obtain detailed records of output on exactly similar lines to those obtained in an electrical supply station.

One scheme, still in the experimental stage, contemplates a still more radical departure, namely, the use of the electric arc for coal carbonisation. The *Gas Journal* records that Mr. J. Mogford, the gas and electrical engineer of Briton Ferry, suggested such a scheme some years ago, and it is added that Mr. C. H. Merz, to whom the idea was submitted, has also interested himself in a system of carbonisation, which it was proposed to combine with the generation of electrical energy. Thus the sharp distinction formerly existing between the electrical and the gas industry is being removed, and it appears possible that in the future the engineer in charge of a gas works will be equally conversant with electrical work.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE LIGHTING OF SLOUGH MOTOR-REPAIRING DEPOT.

WE have received from the Benjamin Electric, Ltd., some particulars of the lighting at the Motor Repair Depot, an account of which was given in this journal last year. It will be recalled that the works occupy a very considerable area, exceeding 600 acres, and many of the sheds offer interesting examples of the lighting of large industrial interiors. Most of the operations carried on in a motor-repair depot are such as to demand uniform general lighting. In view of the movement of cars over the floors it is desirable that lights should be spaced high up out of the direct range of vision, leaving a clear space below. Accordingly the usual method is to instal overhead lights at a level 20 feet or more above the floor, gas-filled lamps in appropriate Benjamin reflectors being invariably employed.

From the numerous illustrations available, reproduced from photographs taken solely by the artificial light, two examples, for which we are indebted to the courtesy of the Benjamin Electric, Ltd., are presented on the following pages.

The first of these shows the lighting of the Power Station which supplies the whole of the Depot. The general lighting is effected by two rows of six 300 watt gas-filled lamps in Benjamin reflectors, mounted 21 feet above the floor level. We understand that the working illumination exceeds 4 foot-candles and that the consumption of electricity over the working area is approximately 0·65 watts per square foot. Supplementary lamps in parabolic reflectors are used to illuminate the distribution board, a glimpse of which is seen at the side of the illustration.

The second view refers to the Unit and Erecting Shop, where general lighting is again employed. The illustration shows the need of free space for the manipulation of vehicles and uniform illumination over the floor, which is provided by lighting units at a height of 24 feet.

Other large interiors are devoted to stores, vehicle equipment and testing, lorry shelters, etc. In the machine shops, owing to the fact of the area being mainly occupied by lathes, with belting, etc., the lighting approaches more nearly a condition intermediate between local and general lighting, lamps being at heights of 11 and 16 feet according to the nature of the work, and illuminations of 3 foot-candles over gangways and 7 foot-candles over lathes, machines, etc. The whole Depot presents an interesting example of modern lighting with gas-filled lamps, and the methods adopted would enable the sheds to be easily converted to other uses.

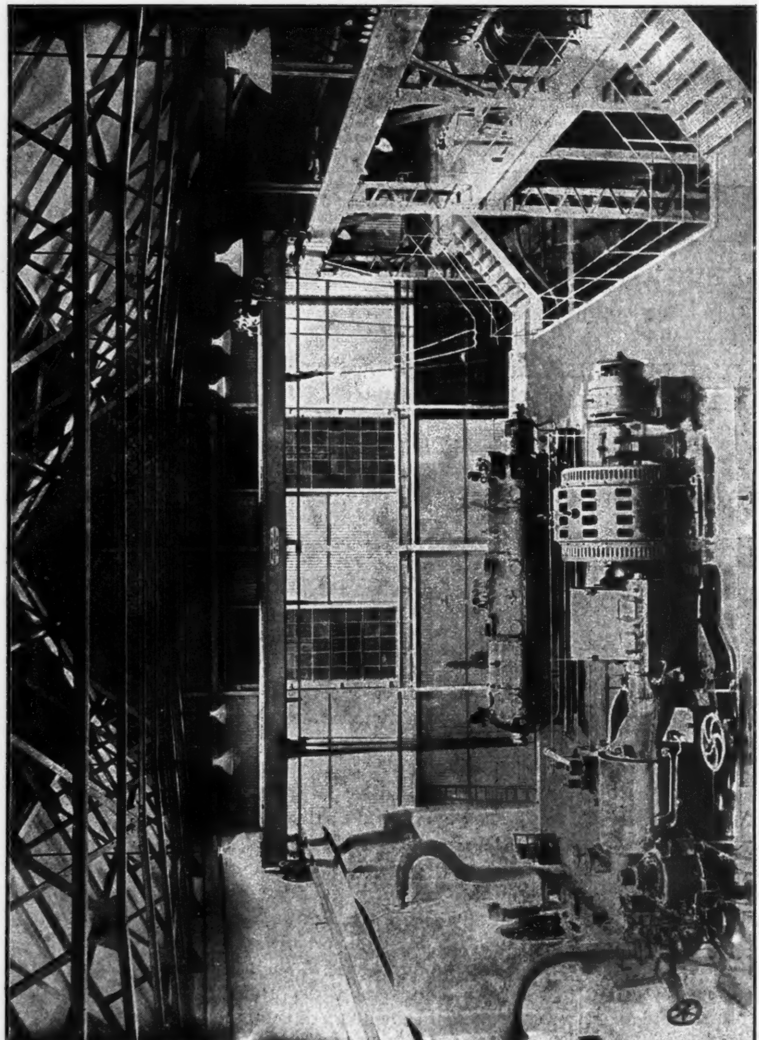

FIG. 1.—A View of the Power Station.

The general lighting is effected by two rows of six 300 watt gas-filled lamps, 21 feet above floor-level, equipped with Benjamin 18 in. concentrating reflectors. The actual illumination is 4·25 foot-candles, and the consumption of electricity is approximately 0·65 watts per sq. ft. over the working area.

The Lighting of Slough Motor Repairing Depot.

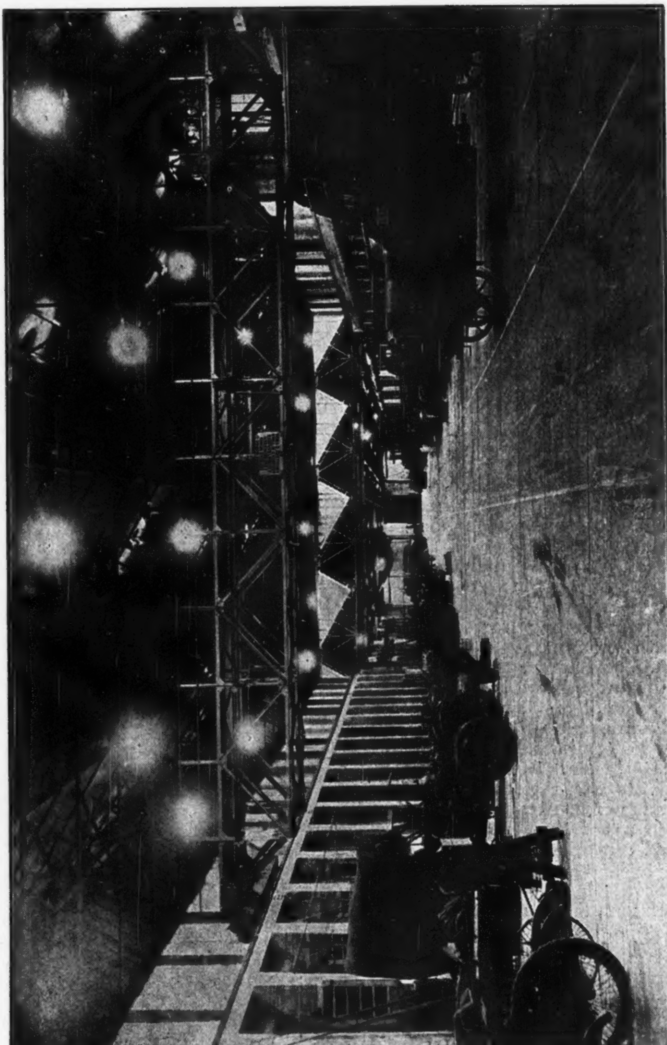

FIG. 2.—A Section of the Unit and Erecting Shop.

There are fifty-one 300 watt gas-filled lamps in Benjamin reflectors, fixed 40 feet apart, in rows of average distance 12 feet apart, staggered, at a height of 24 feet above the floor. The illumination provided is 3 foot-candles.

The Lighting of Slough Motor Repairing Depot.

THE LIGHTING OF A LARGE DRAPERY STORE.

THE large London stores have usually been amongst the first to take advantage of improved methods of lighting, and many have recently revised their arrangements in view of the introduction of the gas-filled lamp.

We are indebted to the General Electric Co., Ltd., for the accompanying illustrations of the premises of Messrs. Stagg and Mantle, of Leicester Square. Practically the whole of these premises, it is stated, are lighted by Osram gas-filled lamps in conjunction with either diffusing spheres or semi-indirect bowl fittings equipped with "Equiluxo" glassware.

The two illustrations on the opposite page show views of Bootwear and Millinery Departments.

THE A.C. POINTOLITE.

A DEVICE for running 30 c.p. and 100 c.p. Pointolites on A.C. circuits of any voltage or frequency has just been completed in the Ediswan Lamp Laboratories.

The device consists of a small transformer and ballast resistance coupled with a small synchronously driven commutator. The commutator is started by a slight twist with the finger. Both half waves of the A.C. current are rectified by the commutator and the arc is thus fed with a unidirectional current pulsating with double the frequency of the supply.

The device is compact, being only 7 in. by 5 in. by 12 in., and is simple and reliable in its working; it has the further advantage of being applicable to other uses where a rectifier of small power is used in small cell charging or electrolytic work.

This device will be on the market shortly. Experiments are being conducted for the purposes of adapting the device to Pointolites of 500 c.p. and 1000 c.p.

"SAFETY FIRST."

UNDER the above title the British Industrial Safety is now issuing a monthly four-page leaflet. The first issue, for October, contains a series of brief quotations from papers read at the recent conference at Olympia, and short readable notes emphasising simple precautions necessary in the interests of safety.

ENGLISH ELECTRIC AND SIEMENS SUPPLIES, LIMITED.

WE are informed that an amalgamation has been completed between English Electric Supplies, Limited, and the Lamp and Supplies Department of Messrs. Siemens Brothers & Company, Limited, and as from November 1st, 1920, the business will be carried on under the title of **English Electric and Siemens Supplies, Limited.** (Registered Office: Brook House, 191-2, Tottenham Court Road, London, W.1.)

The Supplies Department with showrooms and stores at 38 and 39, Upper Thames Street, London, E.C.2, will be retained and all orders and business in connection therewith will be dealt with from that address as heretofore. The same staff will be retained both in London and Branch Offices. The business of both companies will be conducted on the same lines as formerly and with the same products, with the addition of new electrical devices to be shortly placed upon the market.

All orders unexecuted and all obligations entered into by English Electric Supplies, Limited, will be carried out by English Electric and Siemens Supplies, Limited.

PERSONAL.

WE understand that Mr. H. J. Read, M.I.E.E., who severed his connection with Messrs. Edmundsons' Electricity Corporation in March last, after a service of over thirty years, has joined forces with Mr. H. J. Butcher, A.M.I.E.E., and Mr. W. J. Bransom, A.M.I.E.E., both of whom were on the staff of Messrs. Edmundsons for thirty and twenty years respectively, and with Mr. D. Dunham, B.Sc., recently in the service of the British Thomson Houston Co.

Under the title of Read & Partners, Ltd., they are specialising in electrical installations for country houses, farm works, etc. They have now established their permanent address at 53, Victoria Street, Westminster, S.W.1, where all communications should be addressed.

Mr. Jas. Garnett, who was for ever thirty years with Messrs. Edmundsons, has joined the staff of the new company.

FIG. 1.—Bootwear Department of Messrs. Stagg and Mantle, Leicester Square.

FIG. 2.—Millinery Department of Messrs. Stagg and Mantle, Leicester Square.

The Lighting of a Large Drapery Store.

A VISIT TO THE ELASTA LAMP WORKS OF POPE'S ELECTRIC LAMP COMPANY.

ON Monday, December 6th, a visit of the Press took place to the Elasta Lamp Works of Pope's Electric Lamp Co., Ltd., at Willesden. It may be recalled that these works were started in 1904 by Mr. F. R. Pope, originally on a small scale, but have been gradually extended to their present size in order to accommodate new machinery and additions to the staff.

The visitors were afforded an opportunity of witnessing the operations throughout the entire works, where carbon filament, vacuum metal filament and gas-filled ("half-watt") lamps are all manufactured. The first operation inspected was the treatment of the molybdenum oxide which furnishes the supports for the filament; this is reduced to a grey powder in the electric furnace and is then pressed into square rods, sintered, hammered and drawn into wire.

The first stage in the manufacture of the lamp proper is the division of the glass tubing into suitable lengths by circular saws, after which the flanges are formed and the piece is ready to receive the platinum leading in wires. "Foot-building," the next process, consists in making the studs, and inserting the top and bottom supports for mounting the tungsten filament, to which the correct shape is given by formers.

The bulbs are washed and dried and sent to the "stemmers," who attach to each bulb a hollow stem of glass by which, at a later stage, the air is exhausted. The filaments are sealed in by special automatic machines and the lamp is now ready for examination, so that any possible defective specimens may be rejected, prior to exhaustion of the bulbs. The production of the vacuum involves pumping in rough and fine stages, the perfection of exhaustion being tested by an induction coil. A further test is the flashing of the filament after which the lamp is sealed off, and dispatched for another inspection, ultimately being examined in the photometer room where they are classified in the proper category of voltage and wattage.

Lamps are now capped, a special non-hygroscopic cement being used, and after a final examination are etched with the name of the firm and the usual details on the bulb; they are then ready for the packing department.

The treatment of the gas-filled lamp is in many respects similar, but the tungsten wire for the filament is in this case "spiralised" on a special machine and is also mounted in the bulb in a somewhat different manner.

A further difference is that, after exhaustion, the bulbs are filled with inert argon gas—this being the variety of gas found best suited to the smaller types of "half-watt" lamps.

The manufacture of carbon filament lamps is again different, one important process being the flashing of the filament whereby a uniform and homogeneous surface is produced. Apart from the standard types of carbon, vacuum metal filament and tungsten gas-filled lamps special varieties for traction, ships, railways, etc., are also manufactured.

Finally it is of interest to mention that the firm has an excellent mess-room for the workers, and a social club attached to the works, which is much appreciated.

After the inspection of the works the visitors were entertained to luncheon at the Trocadero Restaurant, when an address was given by Mr. F. R. Pope, one of the pioneers in the electric lamp industry, and a vote of thanks was proposed on behalf of the visitors by Mr. L. Gaster.

ENGLISH ELECTRIC AND SIEMENS SUPPLIES, LIMITED.

THE Sales Department of this Company (also of Messrs. Siemens Brothers and Co., Ltd.), formerly trading at Central House, New Street, Birmingham, have removed to new premises, and in future their address will be :—

English Electric & Siemens Supplies Limited,
White House,
111, New Street,
Birmingham.

Telephone : Midland 964.
Telegrams : Siemens, Birmingham.

GAS LIGHTING WITH HOLOPHANE REFLECTORS IN A BOOT FACTORY.

By the courtesy of Holophane, Ltd., we reproduce herewith a photograph, taken entirely by the artificial light, showing the conditions of illumination in a boot-factory at Northampton, lighted by gas. The room shown is devoted chiefly to the interesting "closing" process in making boots, and it is of great consequence, not only to provide a particularly high illumination, but to ensure that the lighting unit is in the correct position with regard to the work.. Accordingly, special local lighting is provided, one unit to each two machines. The actual illumination at the point of the needle is 14 foot-candle, while over the working area of the fitters' table 12—16 foot-candles is provided.

Fig. 1.—Showing General View of a Section of a Boot Factory Lighted by Incandescent Gas Burners with Holophane Reflectors.

The general view shows both a number of the machines and a fitter's table. The burners are of the low pressure type, provided with Holophane aluminium-covered reflectors. The centres of lighting units are located 1 ft. 9 in. above the needles of the machines, and 2 ft. 6 in. above the work on the fitter's table. A second illustration shows the exact nature of the machine, and the position of the lighting unit on the right hand of the worker.

The actual mantles are screened from the direct view of workers, and the installation affords a typical example of the use of scientifically designed reflectors with gas burners.

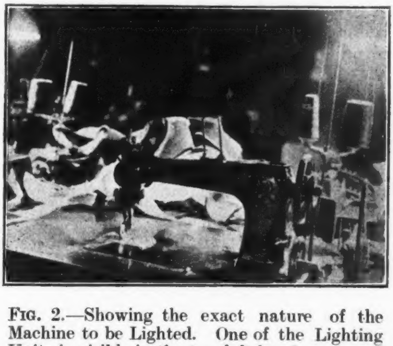

Fig. 2.—Showing the exact nature of the Machine to be Lighted. One of the Lighting Units is visible in the top left-hand corner of the picture.

IMPROVEMENTS OF STREET LIGHTING IN THE WEST END.

FIG. 3.—Night Photograph, showing lighting conditions in Northumberland Avenue.

WE have recently referred to the improvements made in the lighting in Whitehall and other streets in the vicinity. We have now received from the General Electric Co., Ltd., some fuller particulars of the new lighting units installed.

It is stated that the Charing Cross Supply Co. put in the first installation of open type arc lamps about 20 years ago. These were replaced later by flame arcs, but during the war 100 watt gas-filled lamps were substituted in the arc lamp cases as a measure of economy. When the time came to restore pre-war lighting conditions it was decided to adopt gas-filled lamps and suitable fittings as a permanent installation.

The area in which the new system has been installed includes the Strand, St. Martin's Lane, Northumberland Avenue, Trafalgar Square, Leicester Square, The Haymarket, Long Acre and part of Charing Cross Road and Whitehall. In all 122 standards have been converted, and each one is equipped with two lanterns each containing 750 watt "Osram" gas-filled lamps and fittings, and including a reflector in white vitreous enamel and Holophane refractor globes, provision being made for adjusting the lamp to the correct focal position.

In order to illustrate the nature of the illumination obtained readings were taken in Northumberland Avenue where the lamps are 25 feet high and 160 feet apart. The maximum illumination recorded directly under the lamps is 2·6 foot-candles, the minimum between the standards is 0·3 foot-candles; the diversity factor is thus 8·6, which is regarded as a very satisfactory result.

The installation was designed by the Illuminating Engineering Department of the General Electric Co., Ltd., to the specification of Mr. W. B. Thorpe, Chief Engineer of the Charing Cross and West End City Electricity Supply Co., by whom permission to publish this description has been accorded.

PUBLIC GAS LIGHTING IN WESTMINSTER.

We observe that at the meeting of the Westminster City Council on September 16th a report was presented dealing with the public gas lighting contract. The report mentions that notice of termination of agreement dealing with the installation and maintenance of public lighting in certain districts of the City of Westminster had been received from the Gas Light and Coke Co. In particular, exception was taken to the conditions relating to lamps giving a light below the contract minimum candlepower. Draft conditions in respect to the testing of lamps, under which they would be prepared to continue the lighting, on the present terms, were submitted by the company. Should these not be agreed, they would be willing to refer the question to arbitration by an impartial lighting expert. We understand that at a subsequent conference a satisfactory agreement was arrived at.

INDEX, October-December, 1920.

SPECIAL NOTICE.

COMBINED OCT.-NOV.-DEC., 1920 ISSUE.

The ILLUMINATING ENGINEER, in common with other technical journals, experienced difficulties in maintaining the regular issue of numbers during certain periods of the war. Although it was fortunately found possible to maintain continuity of work, delays and interruptions occasionally occurred, with the result that ultimately the month indicated on the covers of numbers fell behind the actual date of publication.

This discrepancy has given rise to inconvenience, and at the request of some of our supporters we have decided to remove the anomaly by combining the final three months of this year in one issue (forming the twelfth number actually issued in 1920), together with the index for the year.

We believe that the opportunity thus afforded of bringing this issue of the journal more up to date will be appreciated by advertisers and subscribers as an arrangement of mutual benefit, and in the near future the actual date of issue will accordingly correspond with the month marked on the cover.

"INCANTO" ACETYLENE LIGHTING.

As is well known, acetylene was very largely used during the war for welding operations, and for portable lamps used in camps and field hospitals. Meantime, the development of this system of lighting for country houses, etc., was naturally checked by these urgent demands for war work. With the resumption of more normal conditions, however, there should be good opportunities for progress in this field, and we are interested to see that leading firms are taking steps in this direction. A case in point was afforded by the Ideal Home built on the north terrace of the Crystal Palace, which was lighted by the "Incanto" acetylene system.

THE "CITY" LANTERN.

We have received from the General Electric Co., Ltd., some particulars of the "City" Lantern, which, it is stated, has been widely used for street lighting, and in railway goods yards, stations, colliery sidings, shipbuilding yards, and other open spaces.

The lantern was designed to embody the following characteristics: (1) a wide distribution of light; (2) facilities for easy adjustment and cleaning; (3) efficient ventilation; (4) watertight and substantial construction; (5) handsome appearance.

The reflecting surface is of white vitreous enamel and can be easily cleaned, and a special ratchet device is provided to insure that the position of the lamp can be easily adjusted to the correct focal position. Special attention has also been paid to adequate ventilation. Lamps can be supplied with clear flint or opalescent glasses, and a modified form to take Holophane refractors has also been produced.

VERITAS MANTLES.

A recent catalogue (No. 459) issued by Messrs. Falk, Stadelmann and Co., Ltd., deals with upright and inverted mantles of various types and qualities. It is interesting to note that types of mantles are provided for petroleum, spirit, petrol air gas and acetylene incandescent lamps, as well as for high and low pressure gas lighting. It is pointed out that these mantles are made by British labour at the Company's works at Wandsworth.

SIR ISAAC PITMAN AND SONS, LTD.

New Address.

Sir Isaac Pitman and Sons, Ltd., the well-known publishers of scientific, technical and commercial text books, have removed to new premises at 39-41, Parker Street, Kingsway, W.C., and the firm has issued a booklet describing the progress of the company. It will be recalled that the firm of Whittaker and Co. was recently incorporated, and other businesses have since been acquired. During a recent visit we had an opportunity of judging the commodious nature of the new premises, and admiring the fine library in Adam style (which we understand is to be lighted by semi-indirect methods).

An invitation is extended to teachers, authors, booksellers, etc., to call at the new offices.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

It is announced that a licence has been issued to the British Motor Cycle and Cyclecar Research Association, which has been approved by the Department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. The Association may be approached through Major H. R. Watling, "The Towers," Warwick Road, Coventry.

A licence, under Section 20 of the Companies (Consolidation) Act, 1903, has been issued by the Board of Trade to the following Research Associations which have been approved by the Department as complying with the conditions laid down in the Government Scheme for the encouragement of industrial research:—

The British Silk Research Association (Secretary: A. B. Ball, Esq.), Kingsway House, Kingsway, London, W.C.

The British Music Industrial Research Association, which may be approached through Dr. R. S. Clay, Northern Polytechnic Institute, Holloway, London, N.

Sir John Francis Cleverton Snell, Member of Council of the Institution of Civil Engineers and Past President of the Institution of Electrical Engineers, has been appointed by an Order of Council dated the 23rd day of November, 1920, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.